

Spectacle de la Nature:
O R,
NATURE DISPLAY'D.
BEING
DISCOURSES
On such PARTICULARS of
NATURAL HISTORY
As were thought most proper
To EXCITE the CURIOSITY,
AND
FORM the Minds of YOUTH.

Illustrated with COPPER PLATES.

VOL. III.

Translated from the Original *French*.

The FIFTH EDITION.

L O N D O N,

Printed for R. FRANCKLIN, in *Covent-Garden*; C. DAVIS, in *Pater-noster-row*; and J. PEMBERTON, in *Fleet-street*.

M. DCC. XL.



The Explanation of the CUTS of the Third Volume.

The Frontispiece.

AT the Head of this third Volume, which treats especially of the Course of the Waters, we cannot propose an Example of a Prince that has better employed that rich Present of Nature, than *Lewis the Fourteenth*. The Water-Works of his Royal Palaces are the Admiration of the whole World: But nothing in that kind is comparable, both for the Usefulness and Boldness of the Undertaking, to the Canal he ordered to be made through the Province of *Languedoc*, from the Cape of *Cette*, quite to *Toulouse*; which discharging itself into the River *Garonne*, joins the Ocean with the *Mediterranean Sea*. *Lewis the Fourteenth* is represented here, ordering Mr. *Colbert* to give him an Account of the Project that had been presented by Mr. *Riquet*, and giving his Orders for the Execution thereof.

Fishing. Page 54.

The two Fishermen which are in the Boat sling the Net, called the Scan (*). See the same Fishing at Sea, &c. drawn more at large. *Plate XVII.*

The two other Fishermen, which are going towards the Entrance of the Rivulet into the River, are ready to make use of the Pocket-net (†), and of the raking Pole, which one of them carries on his Shoulders.

The Net that is drying upon the Land just by, is a Sweep-net with its Wings. It is laid upon the Shore, after the same manner as they place it in the Water.

The Animals that live in Mountains. Page 113.

A. The Rain-deer of *Lapland*. B. the Elk. C. the Bear. D. the Antelope. E. the Civet-cat.

The Rain-deer has been painted by Mrs. *Basseporte*, from one that was sent from *Stockholm* to *Paris*. The others are taken from the Figures of *Sebastien le Clerc*.

The first Figure of the Section of a Ship. Page 128.

Mr. *Du-Puy*, a Master of the Requests, and ancient Intendant of *New-France*, has been pleased to chuse him.

(*) A Drag-net. (†) A Net in the Form of a Bag set upon a Hoop.

self, what he thought might be sufficient here for what belongs to Navigation, and to give himself the Explanation thereof (§).

A. The Keel. B. the Stern-post. C. the Stem. On the Keel are laid the Floor-timbers or Ribs, which are flat between 3 and 4, and round both between 2 and 3, and between 4 and 5. Likewise on the Keel are laid the Dead-wood, which are small Ribs in Form of Forks, between 1 and 2 of the Stern, and 5 and 6 of the Head. On the Ribs is laid the Keelson. D. which covers and joins together all the Ribs. E. the Stern. F. the Head. G. the Rudder. H. the Tillar, to which is fastened the Handle or Whipstaff, which goes up to the Quarter-deck in M. I. the Lower-gun-deck. K. the Middle-gun-deck. L. the Upper-gun-deck. M. the Quarter-deck. O. the Gunnel. P. the Hold of the Ship. It is all the Space that is from the Lower-gun-deck I. to the Keelson D. Q. the Main-pump. R. the After-pump. S. the Bit-pins; several Pieces of Wood, to fasten the Cords belonging to the Yards. T. the Knees, that serve to support the Bit-pins. V. the Ladder of the Hold. X. the Partitions. Y. the Main and Jear-capstan, the Use of which is to raise great Weights. Z. the Stairs between Decks. †. the Port-holes, with their Cannons. ††. the Hawse-holes, under the Head of a Ship, through which the Cables run. 1. The Main-mast. 2. The Mizzen-mast. 3. The Fore-mast. 4. The Boltsprit.

The Second Figure of the Section of a Ship. Page 128.

As the whole Inside of this Ship is shaded, the Letters are not placed upon, but over-against the Pieces they relate to.

A. The Main-mast. B. the Mizzen-mast. C. the Fore-mast. D. the Bow-sprit. E. the Round-house. F. the Great-cabin, where the Council is held. G. the Captain's Cabin. H. the Gunner's-cabin. I. the Hold divided into several Rooms, or Partitions, viz. K. the Wine-room (*). L. the Powder-room (†), under the

(§) In the Translation of the Sea-terms and other Things belonging to Ships, I carefully consulted Sutherland's Ship-builder's Assistant.

Some Particulars wherein the French Ships differ from the English, are hereafter remarked.

(*) The Bread-room in the English Ships.

(†) This in the English Ships is always next the Head of the Ship.

Lower-

The Explanation of the Cuts.

v

Lower-gun-deck. M. the Bread-room. N. the Bacon-room. O. the Place wherein the Water is kept. P. the Well. Q. the Master's Store-room, wherein the Sails, and the Surgeon's Chest are kept. R. the Cable-room. S. the Lion-room and Prison (||). T. the Cook-room, under the Fore-castle. It is not always in the same Place. V. the Main-deck. X. the Tasferrel. Y. the Head-rail. Z. the Gunnel, and three Tire of Guns.

The third Figure of the Section of a Ship of the First Rate.

Page 128.

A. The Main-mast, with all its Appendages. 1. The Main-yard. 2. The Main-sail. (The 2. is not in its proper Place in the Figure. It should have been put under the Main-yard 1. where the Sail is furled.) 3. The Main-top. 4. The Cap or Tenon, which serves to join the Ends of the two Masts, and covers the Top of the Main-mast. 5. The Main-top-mast. 6. The Main-top-sail, with its Yard. 7. The Main-top-gallant-trussle-trees and Cross-trees. 8. The Main-top-gallant-mast. 9. The Main-top-gallant-yard, with its Sail furled. 10. The Flag. B. the Mizzen-mast. 11. The Mizzen-yard, with its Sail furled. 12. The Cross-jack-yard, that carries no Sail, but serves to spread the Mizzen-top-sail. 13. The Mizzen-top. 14. The Mizzen-top-mast. 15. The Mizzen-vane. C. The Fore-mast. 16. The Fore-yard, with its Sail furled. 17. The Fore-top. 18. The Fore-top-mast. 19. The Fore-top-yard, with its Sail spread. 20. The Fore-top-gallant-mast, with its Yard and Sail furled. 21. The Fore-vane. D. The Bow-sprit. 22. The Sprit-sail-trussle-trees, and Cross-trees. 23. The Sprit-yard and Sail furled. 24. The Sprit-sail-top-mast. 25. The Jack-staff, with the Jack. E. the Ancient. F. The Lanthorn. (The Letter F has been omitted in the Figure: it should have been put near that large Lanthorn, which is at the Stern) G. the Galleries. (The G is not well in the Figure. It should have been put by the Galleries that jut out under the Stern) H. the Main-stay-sail furled. (The Engraver put I. for H.) I. The Long-boat. K. The Skiff. a. The Shrouds: Cords that serve both to strengthen the Masts, and for Ladders. b. The Back-stays, that strengthen the Top-

(||) *The Powder-room in English Ships.*

A 3

mast.

maſt. c. The Stays. d. The Lifts. Near the Mizentop-maſt, and near the Sprit-top-maſt, the Engraver put a. inſtead of d. e. The Sheets. f. The Braces to govern the Yards. g. The Clew-lines. h. The Tacks, to keep the Corner of the Sail ſteddy, drawing contrary to the Sheet. I. the Crow-foot, which is compoſed of ſmall Cords ariſing from a Block or Centre, and faſten to the Top, in order to ſave the Top-fail, when it is handed, or taken in.

A Ship with all her Sails ſpread. Page 128.

This Ship ſtands large with a fair Wind, having all her Sails ſpread, except the Bowſprit-fail, and the Stay-fails. A. the Main-maſt. A a. the Main-fail. A b. the Main-top-fail. A c. the Main-top-gallant-fail. B. the Fore-maſt. Ba. the Fore-fail. B b. the Fore-top-fail. B c. the Fore-top-gallant-fail. C. the Bowſprit. Ca. The Sprit-fail furled. C b. the Sprit-fail-top-fail furled. D. the Mizentop-maſt. Da. the Mizentop-fail, in Form of a Triangle. D b. the Mizentop-fail. D c. the Mizentop-bonnet, or ſmall Additional-fail. E a. the Ancient. E b. the Flag. E c. the Jack. F. the Poop-Lanthorn. G. Vanes, which ſerve to ſhew which way the Wind blows. The Ancients and Standards ſerve to diſtinguiſh the Nations. The Pendants, Streamers, and particular Flags, ſerve to diſtinguiſh the ſeveral Commanders, or to give particular Signals, in the Day-time. As to the manner of placing the Flags, and of ſtriking and lowering them out of Reſpect, there is a certain Ceremony regulated or agreed to among Nations; but often diſputed in many Points. H. the Stern: The Galleries, &c. K. the Cat's-head: Pieces of Wood, which ſtand out at the Head of the Ship, to ſupport the Anchor. L. the Anchor. It is a great Bar of Iron terminating in two Arms, or ſharp Hooks. It has alſo at the End a Ring, to which the Cable is faſtened, and a Stock, or long Piece of Wood, which ſtands croſs-ways, or at right Angles with the two Arms. The Anchor, not being able to reſt upon one of the two Extremities of the Stock, falls neceſſarily on one Side, and always preſents to the Ground one of the Hooks; which taking hold of it, holds the Ship. M. the Reeves or Oilet-Holes, with ſhort Strings running croſs the Head of the Sail, by which the Sail may be taken up, or made leſs, as there is Occaſion.

The.

The Manner of launching a Ship in the Water. Page 160.

A Ship is launched into the Water, when all its outside Work is entirely finished, and there only remains the Inside to be fitted up.

A. The Cradle. Long Pieces of Wood, which are put on each Side of the Keel. B. a Rope to hold the Ship. C. Wedges of Wood, which one drives in to set the Ship free. D. Men who draw forwards. E. a Carpenter who cuts the Props and the Rope.

The Section of a Galley. Page 131.

A †. The Keel upon the Stocks, in order to the Building of a Galley. B. the Main-mast in the middle of the Vessel. B. the Fore-mast, or Trenchet, standing close to the Head. C. the Main-sail-yard, or Antenna. C. the Fore-sail-yard. To these are fastened the Scuttle-yards, to lengthen the others. D. the Main-scuttle-yards. D. the Fore-scuttle-yards. E. the Main-shrouds. E. the Fore-shrouds. F. the Main-mast-head. F. the Fore-mast-head. G. the Tops, or Gabie. H. the Main-pendant, and the Fore-pendant. I. the Streamers. K. the Flags. L. the Ancient. M. the Main and Fore-lifts. O. the Poop. P. the Arrow, (*) a sort of long Pole, with a long Head to it. Q. the Tillar. R. the Escontre (†). S. the Rudder. T. the Espale, or first Seat of Rowers in a Galley. V. the Escal (||). X. the Prow, or Sperone in *Italian*. Y. the Rembade, or Fore-castle. Z. the Steerage, or Place where the Compass is placed. &. the Great-cabin. a. The Escandolat, or Captain's Store-room. b. the Powder-room. Then follow the Rooms for stowing Legumes, Wine, and other Victuals, as far as c. This Part is called the Compagne. d. the Tavern, after which are the Rooms for the Sails, the Ropes, and the Surgeon's Cabin, as far as e. which is the Tolar or Hospital. f. the Coursey or Corsia, in *Italian*, which is the Passage from the Prow to the Poop of the Galley, between the Banks of Rowers. h. Rails, along which are placed Swivle-guns. ††. an Oar, which consists of its Blade 1, its Rest 2, its Handle 3, and its Round 4.

The Boat of which one sees a Section behind the Galley, is called the Caïque or Skiff in the *Mediterranean*.

(*) In French *la Fleche*.

(†) The French Name.

(||) The French Name.

A Fisher's Boat. Page 135.

This large Boat has two triangular Sails, which the Fishermen are going to strike or lower, after they shall have let the Anchor drop. The two Pieces of Wood which are floating near the Cables, are called Buoys. They are fastened to the Anchor with a Cord, called the Buoy-line, and serve to shew where the Anchor lies. The Fishermen that are on the Shore, draw out of the Water the Drag-net they have flung into it. The other Boat is a *Venetian Gondola*.

The Figure of a small Vessel. Page 135.

This Vessel is called a Høy, or Bilander, being a sort of *Dutch Vessel*. Sloops, and other small Vessels, are much of the same Kind. They serve to carry Goods aboard the large Ships, but especially to enter with the Tide into Rivers, where large Vessels might run the Risk of running a-ground, by drawing too much Water.

A. This Vessel is rigged after the Hoy-manner, with a Mast to let down. B. It has a large Rudder, to take more Hold of the Water. C. It has at Starboard and Larboard, that is, on its right and left Side, a Lee-board, which is made of several Boards fastened together, of an oval Form, much like that of the Sole of a Shoe. This Piece of Wood, when let down into the Water, especially into a River, bears up that small Vessel against the Resistance of a contrary Wind; and by opposing to the Water a larger Surface, on a Line that is parallel to the Side of the Vessel, it diminishes the Lee-way, and keeps the Vessel from going from its Course.

The Thornbacks. Page 142.

A. The Thornback, seen on both Sides. B. The Cat-Fish, a sort of Shark, whose Flesh eats very well. The Form of its Mouth and Gills may be remarked. The same Order is found in all the different Kinds of Sharks. C. the Cod. D. the Torpedo or Cramp-fish. E. the Fire-flaire. F. the Orbis or Globe-fish. G. the Sun-fish. H. the Cuttle-fish; a sort of Pourcontrol or Polypus.

Whereas the Number of the Sea-fishes is almost infinite, we have been forced to limit it to those Figures which are more particular than the others, not to make this Volume too big.

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The Crab-Fishes. Page 147.

A. The Spider-crab seen above and beneath. B. the Crab seen above and beneath. C. the great Lobster. D. the Shrimp. E. the little Sea-horse. F. the Soldier-crab. G. the same sheltered in a Shell it found empty. H. the Pipe-worm in its Hole, which it lengthens and widens as it grows. I. the same seen naked out of its Pipe. K. the two Graters or Files that are round its Head. L. its Tail and two Wings. M. the Orifice or Hole, through which it has a Communication with the Water, and draws it in, or flings it out, as it needs.

The univalve Shells; that is, those that are of a single Piece. Page 150.

A. The Limpet. B. the Venus-ear, or Sea-ear, seen outwardly and inwardly. C. the *Indian* Limpet. There are several other Kinds of Limpets. D. the Button-fish, with the Tubercle, that is jointed into the biggest End of that Prickle. F. another Kind of Button-fish. G. G. the Bodies of several Button-fishes, the Prickles of which have been taken off, and resembling Buttons. H. Centre-Shells. These are so many Cells for small Fishes of the Oyster-kind. I. the Star-fish. The Figure that looks like an Heap of small Snakes, at the upper Part of the Cut, before the Limpet. A. is a Quantity of Pipes of a hard Matter, wherein many Sea-worms did live.

The univalve Shells that have a spiral Form. Page 151.

A. The Sailor. B. the same with a Part of its Outside broken, that the Order of all the little Partitions within may be seen. C. the thin chamfered Sailor. D. the concave short Whirl. E. G. the Silver-whirl, with its Cover or Operculum. H. the great Whirl. I. the same cut from one End to another, through the middle, that the Inside of it may be seen. K. the Sea-spider. L. the fingered Whirl.

The Continuation of the univalve Shells of a spiral Form. Page 152.

A. The Mitre-shell. B. the Harp. C. the Top-whirl. D. Blackamore-teeth. E. the Unicorn-shell. F. the Purple-shell. G. the Spider-shell. H. the Musick-shell. I. the great muricated Whirl. K. the golden Trochus.

The

The Explanation of the Cuts.

The most full of Prickles among these last Kinds, as the Purple-shell, the great muricated Whirl, and the great Spider-shell, are of those which the Ancients called Purples, or Purple-fishes, because they took that rich Colour out of them. We chose those only whose Differences are very sensible.

The Bivalve-shells, or those that are of two Pieces.

Page 153.

A. The Oyster seen inwardly and outwardly. B. the smooth Cockle. C. the Lampin, or Sand-muscle. D. the Muscle. E. the fat-crowned Cockle. F. the long gaping Cockle. G. the Heart-cockle. H. the Razor, or Sheath-fish. I. the great furrowed Scallop. K. the Inside of the Naker, or Mother of Pearl, and the Situation of the Pearls. L. Sea-nettle opened, and seen face-wise. M. the same shut, and seen sideways. N. the same spread. The Dictionary of the Shells is not yet settled.

The Choice we made of the Kinds that differ most from one another, is sufficient to give the Reader a Hint of the wonderful Variety that is in all this Part of Nature; for there is almost none of these Kinds, that is not subdivided into many others, which besides the common Resemblance that unites them under the same Genus, have a particular Form that distinguishes them from any others.

The Sea Plants. Page 155.

A. The Oar-wood. Its Leaves are sometimes many Ells long. B. Its Fruit shut up. C. Its Fruit opened, with its Seed visible. D. the Sea-moss. e. the same seen in a Microscope. E. the Silk-sea-weed. e. the same seen in a Microscope. The small Points that are seen on this Kind of Weed and on the others in a Microscope, are so many little Shell-fishes very regularly made, that live on the Branches of that Plant to which they stick. F. another Wrack or Sea-fern. d. The same seen in a Microscope. G. the Oyster-weed, the Leaves of it are limber, and resemble a Cloth. g. the Leaf of it seen in a Microscope. The Regularity of the Masses of that Texture shews it to be an organized Plant, and an uniform Vegetation.

The Continuation of the Sea-plants. Page 157.

A. The Sea-fan, a Lithophyte or half-stony Plant. B. another stony Plant. C. the same in a Microscope. These

These Examples will be sufficient in that Kind, to shew again, that there is a perfect Regularity, and a constant Order, and not a casual Generation, as is that of the Stalactites, or stony Icicles, in the Vaults that drop Water. D. the Brain-stone. E. the same seeded with Stars. F. G. Madrepores full of Branches. H. Madrepore full of Leaves. Some Virtuoso's call this the Pink. I. the Coral. K. the same seen in a Microscope, with the Places wherein the Flowers are inclosed in Form of Holes made like Stars, in the middle of each Tubercle. L. the Coral newly drawn out of the Sea, and spreading its Flowers in a Vessel full of Sea-water. The inward Substance of the Coral is all Stone, and increases by the Application of a sort of milky Juice, that hardens under the Rind. The Vegetation seems to be only in the Rind.

Coral Fishing. Page 158.

A. The prominent Parts of the Rocks where the Coral is found with its Head turned downwards. B. Two large Pieces of Wood, crossing each other at right Angles, with an heavy Bullet at the Centre of them, and a Net on each End. This Machine they let down into the Water, moving it from Place to Place, that the Nets may lay hold on the Coral-branches, which they break off and bring up with them. C. another Contrivance for the same Purpose. It consists of a long Pole supported with two Cords, with a Bullet to keep it steady, and a Bag to draw the Coral away.

Petrified Bodies. Page 250.

A. The Belemnites or Thunder-bolts. B. the Stone called Dendrophore, whereon is the Impression of some Plants, which very probably are a sort of Sea-weed. C. the Serpent-tongues. They are not indeed real Serpent-tongues, but petrified Teeth, come out of the Jaw of the largest Shark *, whose Head is seen here at D. E. the Ichthyopetra, or the petrified Fish. F. the Astroite or Star-stone. It is a Madrepore, the Stars of which have been filled with a crystalline or stony Matter. G. the Button-fish petrified. H. a petrified Snake. In those two last the Shells or Cornua Ammonis are quite dissipated, because of their Thinness. There remains only the Earth

* *The Canis Carcharias,*

that was petrified in them as in a Mould. I. a petrified Fruit. K. these Horns and the pretended Thunder-bolt are, as likewise the Belemnites A. so many petrified Teeth. The smooth Enamel, with which all those Pieces are covered, is a Proof of it. L. the Entrochi. These are probably the Vertebre or Back-bone of some Fish, the hardest Parts of which have been preserved, and then petrified. N. a Bit of the Horn of the Narwall petrified.

Figured Stones. Page 252.

Most of these Stones are of the Kind called Dendrophores.

A. Has the Impression of an Ear of Barley. B. that of several Branches of Fern, &c. C. that of another kind of Fern. D. that of an Elm-leaf. E. that of a Willow-leaf folded. F. that of an Insect. G. is a Piece of *Florentine* Marble, which, they pretend, represents Castles and Ruins, but in reality represents nothing.

The Figures of the Shells are drawn partly from the Life, and partly taken from those of *Bonanni*. The figured Stones are taken from a Book, intituled, *Herbarium Diluvianum*, of Mr. *James Scheuchzer*, a Physician of *Zurich*, and a learned Man, both judicious and laborious. The Petrifications are taken from the *English* Epitome of the *Philosophical Transactions*, and from the *Metallotheca of Mercatus*, printed by the Command of Pope *Clement* the Eleventh.

The Delft Ware-Potter, working on his turning Wheel.
Page 231.

1. The Wheel, which the Potter turns with his Foot upon its Pivot. 2. The Head of the Wheel whereupon the Potter puts the Piece he is to work. 3. The Piece turned by the Potter. 4. A Piece of Wood with which the Potter makes his Piece smooth. 5. The Ruler or Stick that serves to fix the Height of the Piece. 6. The Square. 7. An Iron-tool, that serves to make the Piece perfect, by cutting away the superfluous Earth, when it is half-dried. 8. A Bowl full of Water to use in proper time. 9. Several Lumps of Earth ready to be worked. 10. A Wire that serves to separate the Piece from the Head of the Wheel. The Sponge is at the Foot of the Stick or Ruler.

I did all my Endeavours to give here the Description of a Glass-house, and that of the Forges; but never could meet with any thing tolerable in that Kind.

The Progress of Vegetation. Page 309.

The Sprouts on the first Line.

A. the Lobe of a big Pea, the Sprout of which begins to shoot. a. the Radicle. b. The Head of the Planta-feminalis lying between the two Lobes, to which it is fastened with two Strings. c. the Place of one of the Strings, that did reach into the other Lobe, which has been taken off. B. a Sprout that has been pulled out from between the two Lobes of the Bean. a. the Root sprouting the first out of the Bean. b. the first Leaves that did lie between the Lobes, and are a sort of Case to all the others. c. the Traces of the two Strings or small Veins, through which the Sprout did draw its Nourishment from the Lobes. C. the Sprout of a Pea grown stronger. 1. the Radicle. 2. the Leaves still tender, and wrapt up in a stronger one. 3. D. a Grain of Corn that begins to sprout out. 1. the Case within which the Roots are inclosed, and which sprouts out the first. 2. the Case of the Leaves sprouting after, but fastened with a String to the Bag that contains the Seed with which the Sprout is nourished. E. the Sprout grown stronger. 1. the chief Root sprouting out of its Case. 2. two lateral Roots sprouting out of two other Cases that did contain them. F. the same unfolded and increased. G. the Case of the Leaves that begins to spring out of the Earth, and to draw its Subsistence from the Juices of the Earth. g. the Case of the Seed that begins to wither. H. the same Case grown stronger and opened. h. the first Leaf springing out of its Sheath. I. the Green that begins to shew itself. 1. the Case of the Seed entirely withered. 2. the Orifice or Opening of the first Sheath. 3. the first Leaf that begins to unfold itself, and being a Sheath to the second, which is wrapt up within it, which second Leaf wraps up within it the third, wherein is a fourth one, that encompasses the Ear. Those six last Figures of the Corn in its first springing out, may still be of Use, when you read the twelfth Dialogue of the Second Volume. We shall give another Example of the springing out of the Sprouts.

The

The Cases of the Buds on the second Line of the same Cut.

K. the Bud of an Oak-tree covered on the Outside, with many small Leaves ranged one upon another, like the Tiles of the Top of a House, or like the Scales of a Fish. K. the Cicatrice of the Place from which the Foot-stalk of a Leaf did fall in Autumn. L. the same Order and Symmetry in the Buds of the Plum-tree. †. a small Branch of an Elm, freed of its Covers. a, a, a. are the true Leaves; b, b, b. are preparatory Leaves, or a sort of Scales that did contain and cover the true Leaves. When the Leaves a. are grown stronger, the Leaves b. being become needles, they dry and vanish into Dust. M. the Bud of an Apricot tree. This Bud, which is a Bud for Flowers, begins to bud in *June*, near the Place m. from which the Foot-stalk of a Leaf did fall the last Autumn. This Bud swells by Degrees during the Summer, by the spreading of the smaller Leaves or Scales that cover it, and maintain it during the Winter. The last Leaves which are round at Top, are those of the Flower; they will spread in the Spring. N. the same Symmetry in the Buds of the Almond-tree. But it has besides a sort of Cup, which for a greater Security encompasses the Leaves of the Flower which are yet one upon another, like a Roll. O. the double Cup of a Pink. The lower Cup is the Case of the Second, which will not be open at the Top, before the Flower it incloses be fit to shew itself in all its Beauty.

The Disposition of the Pistillums and Stamina of Flowers.

The third Line of the same Cut.

These Figures are magnified in a Microscope.

P. the Pistillum and the Stamina of the Flower of the Plane-tree, Cherry-tree, &c. Q. the Pistillum and Stamina of the Flower of the Pear-tree. a. the Pistillum or Tube, in both these Flowers. The lower Part of this Pistillum contains the Seed, and the highest receives the Dust that makes that Seed fruitful. b. b. the Tops of the Stamina. These Tops are like Bags full of a fine Dust, which they drop when they are ripe or swelled by the Heat. c, c. the Place where the Seeds of the Pear are. The Body round them is the Pulp of the Fruit. When the Seed has been made fruitful, the Pulp of the Fruit that covers and nourishes it, strengthens every

every Day more and more ; and then the Leaves of the Flower, the Stamina, and the Pistillums, become needles, dry, and vanish away. The Remains of them are seen at the Head of the Fruit, and are called the Crown of the Pear or Apple. R. the Flowers that grow at the Top of the Maize. 1. two hollow Leaves, that serve for a Case to the two following ones. 2. these are the Covers of the three Stamina or Pedicles that support the Tops. 3. there is here no Pistillum to receive the Dust that falls from the Tops of the Stamina: But this Tube is at the lower End of the Stalk in many different Places. The Seeds, and the Bunches or Ears, are to be formed in the same Place. See the Figure of the Maize or *Turkish* Wheat, *Vol. II. Dial. XII.* See the same Division of the Stamina and Seeds, in the Figure of the Pine-tree, *Vol. II.*

These Examples may be sufficient to give a Hint of the right Disposition of the Plants in which the Flower joins the Case of the Seeds with the Stamina, and of the Plants in which the Stamina are in one Place, and the Case of the Seeds in another.

All the Figures I have gathered in this Cut are true, though grossly done. They are taken from the excellent Work of *Malpighi*, who did not multiply his Engravings in order to please and amuse the Publick, but only to render himself intelligible,

The Orbit which the Earth describes in one Year round the Sun. Page 341.

A A. represents the Plane of the Circle or Ellipse the Earth makes in one Year round the Sun ; while every four and twenty Hours it makes a whole Revolution round its own Axis : Just as a Ball that rolls a certain Space, rolls every Minute round itself by the successive rising and falling of all its Points.

When the Earth is in the Sign called *Capricorn*, the Inhabitants of it see the Sun in *Cancer*. When it is in *Aries*, they see it in *Libra*. Thus the Earth attributes all the Alterations of its Place to the Sun, which keeps always in the same Place. Besides, it attributes to the Sun its daily Revolutions, and whilst the Earth turns round before the Sun, it seems that it is the Sun that passes over the Earth.

If the Earth had always its Axis B. perpendicular to the Plane A A. without inclining to one Side more than to the other, it would have the Sun perpendicular to the Æquator D. during the whole Course of its annual Rotation; and consequently the Sun would be visible 12 Hours, and invisible the other 12, to all the Inhabitants of the Earth throughout the Year.

But when the Axis B. of the Earth placed in *Capricorn*, inclines itself 23 Degrees and a half towards the North and towards the Sun, the Æquator D. must needs be 23 Degrees lower than the direct Ray of the Sun. The Sun will then appear to be in *Cancer*, over-against the Point E. 23 Degrees under the terrestrial Æquator. The Earth in its Revolution of that Day, brings successively under the Sun all those Points at the Distance of 23 Degrees from the Æquator. The Sun will therefore seem to pass under all these Points, and to describe the Tropick of *Cancer*.

The Earth, by advancing forwards on its Orbit towards *Aries*, will receive the direct Ray of the Sun, on one of the Points that are between the Tropick of *Cancer* and the Æquator. The Sun will then seem to describe every Day a new Circle parallel to the Æquator.

The Earth when got to *Aries* will see the Sun in *Libra*, and as it keeps its Axis in a Situation parallel to that it had three Months before, in this Case it does not incline it towards the Sun. It receives then the direct Ray of the Sun on its own Æquator, and opposing successively to the Sun all the Points of its own Æquator, it will see the Sun describing that Circle, or passing over all the Nations that live under it. Three Months after, when got to *Cancer*, it will see the Sun in *Capricorn*, and always inclining its Axis 23 Degrees towards the northerly Stars, the more it removes its Axis from the Sun on that Side, the more it inclines it towards the Sun on the opposite Side. If this other Side of the Axis inclines itself 23 Degrees towards the Sun, its direct Ray will then fall on F. at the Distance of 23 Degrees from the Æquator, since the same Ray would fall on D. did not the Axis incline itself at all. It will then be Summer to the Inhabitants of the Austral Hemisphere, and Winter to those of the opposite one. During the three following Months, the

the Earth will oppose to the Sun one of the Points that are from F to D. and bringing under the Sun in each of its daily Revolutions Points equally distant from the *Æquator*, the Sun will seem to describe a Circle parallel to the *Æquator*.

In short, the Earth placed in *Libra*, and inclining neither of the Extremities of its Axis towards the Sun, will receive the direct Ray of it on its *Æquator*, which will form the Spring, and renew the Year. The Inclination alone of that Axis on the Plane of the annual Orbit (provided it be conceived to be always the same, and always parallel to itself) is then sufficient to account for the Diversity of the Seasons. The unequal Length of the Days has its Principle, from the same Inclination of the Axis, and from the manner after which the Horizon of each Nation cuts the Circle which the Sun seems to describe every Day.

The Horizon is the Extremity of the Lands that terminate our Sight. It forms a Circle, in the Centre of which we are, and which is supposed to be visible enough to let us see about 180 Degrees, that is, the half of the Heaven. In the mean time, it hides from us the other half, or the inferior Hemisphere. If we go to the *Æquator*, our Horizon, that reaches 90 Degrees on one Side, and 90 Degrees on the other, terminates necessarily at the Poles, that is, at the two Points through which the Axis passes out of the Earth, since they are at a Distance of 90 Degrees from the *Æquator*. The Circle which the Sun will seem to describe over our Heads, will be cut exactly into two Parts by our Horizon; so that we shall see the Sun 12 Hours together, after which it will be hidden under the Horizon other 12 Hours. As the Earth will advance on its annual Orbit, we shall see that we see the Sun changing its Place, and describing every Day new Circles parallel to the *Æquator*. But these Circles will always be cut exactly into two Parts by our Horizon, on which they are perpendicular, placed, without inclining on one Side more than on the other, since our Horizon, that terminates at the two Poles, cuts them all through the Middle as it does the *Æquator*. If we leave the *Æquator*, all will be altered. If we advance 20 Degrees towards the Pole, our Horizon

be no more terminated by the Pole, but it will be 20 Degrees lower, and then all the Circles described by the Sun will be cut into two unequal Parts. When the Sun appears on this Side of the *Æquator*, the Part of its Way above the Horizon is greater than that under, and then the Days are longer than the Nights. When the Sun is on that Side of the *Æquator*, the Part of the Circle it describes above the Horizon, is less than that it describes under, and consequently the Nights are longer than the Days.

None of these Alterations would happen, if the Earth did not incline its Axis, and if it could always oppose its *Æquator* to the Sun. Such was necessarily the Disposition of the Axis, if there was a perpetual and universal Spring in it, as it seems we might conclude it. *1st*, From the Longevity of the Antediluvians. *2^{dly}*, From the Memory that has been preserved of it in the Writings of the ancient Poets. *3^{dly}*, From the petrified Leaves, Buttons, and Fruits, that are found all over the Earth, and seem to demonstrate, that before the Flood there was at once a perpetual Spring and Autumn: But God had no sooner pushed the Axis of the Earth 23 Degrees further, but the Order of every thing was quite altered; there were new Heavens and a new Earth. This Conjecture has nothing in itself that is any way contrary either to true Piety, or sound Philosophy, since the most skilful Philosophers are wont to see the greatest Effects produced by the plainest Means.

THE
S E Q U E L
OF THE

S E C O N D P A R T ;

Giving an Account of the Surface and
Bowels of the Earth.

P A S T U R E and M E A D O W - G R O U N D S .

D I A L O G U E X V I I .

The P R I O R and C H E V A L I E R .

PR I O R. Since the Count's Affairs oblige him to take this Journey, and to leave us alone, let us not omit visiting every thing in the Neighbourhood which may be entertaining to you, and in some measure make amends for the Loss of his Company. There are several Walks which I long ago determined to propose to you, but have reserv'd them on purpose till now ; let us therefore make choice of one for this Day's Amusement : A rural Scene does every where present us with agreeable Objects ; the Hills, Vales, Woods, Vineyards, Villages, Castles, nay even Ruins, Rocks and Caves, do all together form a pleasing Variety, on which the Eye expatiates with Delight. Now in so charming a Landskip, which of all these do you pitch upon, my

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dear Chevalier, for the Entertainment of your present Walk?

Chevalier. No other than that we are in at present, the Meadow; 'tis that which we visit oft'nest, and quit with the greatest Regret.

Prior. The Vineyard indeed is not so commodious a Walk; the Orchard has something in it too confus'd and irregular; and the long Allies and finest Lanes in Woods, on the other hand, carry too much the Air of Art and Contrivance; besides, the Eye is there too much confin'd, so that we can prevail with ourselves to relinquish all these Places, without any manner of Unwillingness; but the Meadow, after all, does naturally invite and attract our Steps, and we are loth to leave it till the Sun forbids us any longer to survey its Beauties. Give me leave to observe likewise, that it delights more than the most regular and uniform Garden; for after we have taken a Turn or two in the Parterre, and visited the Espalier, we strait grow weary, and find something wanting to crown the Pleasure of Walking, which we no where meet with but in the Meadow.

Chevalier. Yet notwithstanding there is nothing more regular than a fine Garden, nor any thing more void of Art than a Meadow.

Prior. Whatever Beauties we may see in a Garden, yet we find ourselves too much confin'd there, and every Place that terminates our View, seems also to trespass on our Liberty; whereas in a Meadow it is not so; we here fancy ourselves, as it were, more independent, and the Conceit of our Freedom arises in proportion to the Extent of the Prospect which opens to us. Man, who is conscious that the Earth was made for his Use and Delight, cannot endure to be limited, for any long Time, to a small Part of his Dominions; and then only thinks he is in Possession of the whole Compass of his Empire, when in a fertile and spacious Plain he beholds, with a secret Satisfaction, all Nature with open Arms saluting him her Lord and Master.

Nor is this only an agreeable Illusion that feeds our Fancy; for an extensive Meadow is in Reality the Place where Nature has shew'd herself most complaisant to Man, and where she does at once exhibit the greatest Beauty and
Fecundity

Of MEADOWS.

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Fecundity together. In order to recommend this to us as her most favourite Walk, The Beauty of Meadows. she has, for our better Accommodation, smooch'd it with a level Surface, and cover'd it with a verdant, flowery Carpet. She has rais'd delightful Hills on every Side, some of which are placed within the Reach of Sight, presenting us with Objects discernible by the unassisted Eye, whilst others situated at an immense Distance from us, seem to lose themselves in the boundless Prospect: Besides, she has of her own accord so bountifully enrich'd the fertile Soil, as to ease us of the Pains of Cultivation and Husbandry, having sown therein an almost infinite Multitude of Grains, whose Minuteness renders them imperceptible to Sight, whence springs a Verdure, if not perpetual, yet almost as soon reviving as destroy'd.

Chevalier. This is a Phænomenon I cannot easily account for: For Example, when a River happens to overflow its Banks, and to cover the adjacent Meadows with one continu'd Inundation, does not this, consequently, destroy the Roots and the Seeds? How comes it to pass then, that, since nobody sows fresh Seeds in their Room, the Grass does all of a sudden spring again, and recovers its Verdure as before?

Prior. It happens indeed sometimes that the Summer's sultry Heat does scorch the tender Grass, and chaps the thirsty Earth from one End of the Meadow to the other; or, as you observe, that a wintry Deluge overspreads it with Water and Mud, insomuch that one would be apt to imagine that the Seeds were quite parched up with the one, or choaked and rotted by the other; but notwithstanding their Smallness, they are enveloped with several Coats or Membranes which defend the Bud, and render it impenetrable either by Heat or Damp; so that even before the Summer Heats are well over, they begin to sprout afresh; and as soon as the Return of Spring begins to invite Man to go forth into the Fields, the Earth with officious Haste seems pleas'd to deck herself in her green Livery, that thus adorn'd in all her Finery and Glory, she may pay her grateful Homage and Respect at the Feet of her Master.

The Usefulness of
— Meadows.

Let me farther remark to you, that this wonderful Diversity of Plants, which you see overspreading the Face of a single Meadow, is not all for Shew, but each has its distinct Leaf, Flower, Beauty, and Virtue, peculiar to itself.

Chevalier. What! then is it not all one and the same Sort of Grass that we tread upon?

The Principal
Kinds of Meadow-herbs.

Prior. Doubtless you meet with the same very often, but perhaps you take not two Steps without treading on a hundred different Kinds; for Example, this is the Rampion, which we eat in Sallad; a little further you see the little Cresses; this which grows so common every where is the Trefoil, which together with that other call'd Balm-gentle, an Herb of a fine Flavour, and which gives Cream an exquisite Relish, are the chief Glory of the Meads; up and down you will find the Millefoil, the Burnet, the lesser Centory, the Plantain, the little Lyricofancy, the Fumitory, the Agrimony, the —

Chevalier. Give me leave to interrupt you, Sir. In taking a nearer View, methinks I discover several that I know; that, for Example, is the Pimpernel, these here are Daisies, this here has the Shape and Smell of Garlick, and one would take that other for Sorrel.

Prior. It is the very same, Sir.

Chevalier. Pray who has been at the Pains to transplant our Garden-Herbs hither?

Prior. You should say rather, to transplant them hence thither, in order to have them near at hand; for the Meadow was originally our Kitchen-Garden. Now besides these Herbs, of common Use, the Botanists have here discover'd a wonderful Variety of Simples,

which they range under different Genus's, each of which again is divided into many Species; all which Species do indeed agree in their principal Configuration and predominant Qualities, but are distinguish'd from each other by their different Degrees of Smell, Savour and Strength; besides, the same Species does also vary its Properties, according to the Climate or Soil which nourishes it. These are the Herbs which afford us a constant Supply of Medicines, such as exquisite Balsams,

Of MEADOWS.

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sams, stimulating Catharticks, and healing Vulneraries ; nay, the very brute Animals are sure to find a Remedy here for every Distemper, so undeniably does every thing bear the Stamp of the unbounded Wisdom and Goodness of its Creator.

But the chief Benefit we reap from the Meadow is, that it does at its own Expence afford Provision for those Animals

The Pasture of
Cattle and
Horses.

whose Service we stand so much in need of ; the Ox which is fattening for our Table, and that which plows our Land, do both alike subsist on the Grass of the Meadow : The Horse, whose almost perpetual Labours are so useful to us, demands no other Return than the free Use of the Meadow, where, after his Work is over, he sports and plays, and thinks that little Liberty an ample Recompence for all his daily Service ; nor does the Cow, whose Milk not only yields us Nourishment, but Dainties too, ask any thing more of us.

Chevalier. But tell me, I pray, how it is possible that a coarse Herb, and that oftentimes dry and without any Moisture, can make the Flesh of an Ox so fat and juicy ? How a little Hay can give the Horse such Supplies of Strength and Spirits as render him almost indefatigable ? Or how this Grass, when eaten by a Cow, comes to be converted into so rich a Substance as Cream, to which one half of Mankind owes the greatest Part of their Nourishment ?

Prior. Your Surprise is very natural ; for it must be confess'd, that the Juices do in this Case undergo several Changes, Secretions, and Preparations, in a manner almost inconceivable. Let a Man never so carefully pick and cull from among these wild and bitter Herbs any Quantity he shall think fit, and tho' he cook them with all his Art, he will not be able to make a tolerable Mefs of Pottage of them ; and yet there is not one of them but what, after being concocted in the Stomach of the Cow, and pass'd thro' the proper Vessels, does contribute to compose in her Udder one of the most delicious and nourishing Draughts in the World ; so admirably has the all-wise Creator adapted and proportion'd the Qualities of this Vegetable to the Bodies of those Animals which he has made for our Use, as, by the Office of the latter upon the

former, to prepare for us a Potion so salutary as well as palatable.

Chevalier. How ungrateful are the Inhabitants of the Earth, who daily see these Things, and neither reflect upon, nor are thankful for them!

Prior. The Reason seems to be this: We are apt to look upon the Grass of the Field as the common Gift of Nature, which she has every where strew'd under our Feet without any Care or Culture of our own, and therefore are less mindful of the Benefit of it; whereas this very Consideration ought to enhance its Value, and make us the more thankful to our kind Benefactor, who is sometimes provok'd to punish our Ingratitude, by making us feel the Want of so unvalued a Blessing: He sends a Drought, and, lo! the Meadows are parch'd up, all Business of Husbandry is at a stand for want of the Assistance of Horses; and the Cattle, which should feed us, perish themselves for Lack of Sustenance: He gives the Word, and a Blast consumes the Herbage, and Dearth and Scarcity do immediately ensue.

But to give you a more distinct and particular Notion of the Usefulness of Meadows: They are the most beneficial of all our Possessions, they require not our Labour either to plow or sow them, and only cost us the easy Pains of gathering that Crop which they yield of their own Accord; their Produce is not of a precarious, but certain Value; and, in a word, of such necessary Use to us, that without it we can hardly allow other Lands to be of any Worth at all. But then again, on the other side, in order to make the most of our Meadows, we must keep other Ground in our Hands, for they do mutually assist and are profitable to each other; and a good Oeconomist will be sure to preserve a just Proportion betwixt his Meadows and Lands of another Kind. For Example, if you have only Meadow-Grounds, the Cattle which graze therein will yield you Dung which you can make no Use of; on the contrary, if your arable Lands are more in Proportion than your Meadows, they must grow barren for want of Provender to maintain a sufficient Stock of Horses and Oxen to manure and improve them.

Chevalier.

Chevalier. But supposing a Necessity of being contented with one of these two, which, in this Case, would you take?

Prior. Why, under such Circumstances, generally speaking, Meadow is to be preferr'd to arable Ground, for that the former will yield a certain Profit without the Assistance of the latter, and neither puts us to Trouble or Expence; whereas plow'd Lands require a great deal of Cultivation and Management, and turn to small Account where there is a Scarcity of Meadows and Pastures.

Chevalier. Do you make any Difference then betwixt these two?

Prior. Your low Grass Fields which are situated in the Vallies, and by the Sides of Rivers, are generally called Meadows, whereas those which lie on the Sides of Hills commonly go by the Name of Pastures.

Chevalier. Of these two which is the most valuable?

Prior. Each has its respective Advantages. The Slime which is left on the Meadows, by the Overflowing of the Rivers, together with the Dung of the several Sorts of Animals that graze upon them, does never fail to occasion an almost perpetual Fertility and Richness of Soil. The Pastures, on the other hand, have this Advantage, that lying on a Declivity, and consequently less soak'd with Rain, they produce a finer Sort of Grass, and which gives the Flesh of those Animals that feed upon it a more delicious Taste. There are also some Meadows which lie pretty high, that partake of both these Excellencies, and are remarkable both for the Abundance and Delicacy of their Grass; of this Sort are those of *Limagne* in *Auvergne*, and in many Parts of Low *Normandy*.

The most ordinary Kind of Meadow Land is your Marsh; for the very best Marshes. Grass it yields, is always mix'd with Rushes, Flags, and several hard and coarse Herbs, which lacerate the Palates of those Animals which feed on them. It is not indeed without its Use; for, being well dry'd, it will serve for Litter, for Thatch for Out-Houses, or to heat the Oven: But after all our Care and Pains to separate the Good from the Bad, to dry it, to pick out what is

noxious and offensive, and all those Weeds which have a muddy and earthy Smell, breeding malignant and unwholesome Humours, yet we shall never be able to make tolerable Provender of it; and to be satisfied of this, we need only behold the frightful meagre Looks of those Horses, which have nothing else to live upon.

Chevalier. But I remember to have seen some industrious and pains-taking Gentlemen convert their Marshes into good fruitful Meadows, by contriving large Fosses and Drains to carry off the Water, and using the Earth they took out of the Ditches to raise the Flats; and at that Season of the Year, when their Horses are not employed in any other Work of Husbandry, they use them in carrying Gravel and Chalk-Stones upon their Marshes, which the Moles and Worms mix and blend with the natural Soil, and make it incorporate without any farther Trouble.

The Management of the Meadows.

Prior. Nor is that Industry and Care which we find so effectual in curing the Barrenness of Nature, less serviceable in improving her Fruitfulness; for tho' Hay, for Example, is one of her spontaneous Productions, and independent of our Labour; yet the Goodness and Plentifulness of the Crop does, in a great measure, depend upon our Management of the Meadows.

A prudent Husbandman will every now and then visit his Meadows, and where he sees Shavegrafs, Darnel, Hemlock, or Wake-Robin, and other noxious Weeds increase too fast, he will pluck them up by the Roots; or if there is any Scarcity of Trefoil, or of any other Sort of good Grafs, he will order new Seed to be sown, and every four Years enrich his Land with a Compost of Dung, and such Sweepings and Siftings of his Barn, as have not been picked up by the Fowls.

At the Return of Spring, when the Beasts begin to grow tired of their wintery Food, and long for the fresh Grafs, they are turned into the fallow Fields, where the scattered Corn of last Year's Harvest, that dropped from the Reaper's Hand, begins to sprout afresh, yielding here and there a delicious Morfel; or else they are turned out to graze on the Banks of Rivers, the Out-Skirts of the Fields, or the Highway Sides, but in no wise admitted into the Meadows,

Meadows, till the Hay-Harvest is got in, unless where there is a certain Allotment of Meadow-Ground set apart for the common Use of the Inhabitants of the Manor or Corporation, and therefore Commons. called a Common, wherein the Tenants have the Privilege to feed their Horses and Cattle till mowing Time is over, when they set them at full Liberty to feast upon the Rowens. By means of this Caution, the Grass has Time to grow and get Strength in the Manner we see it does in the Months of *April* and *May*, when it seems to exult with a Sense of Liberty, overspreading and adorning the wide extended Plain, with an almost infinite Number of Flowers, as you behold at present, whose various and beautiful Colours receive an heightening Grace from that Verdure which serves them for a Ground. In *June* it ripens into Seed, presently after which, it comes to the Age of Maturity, and is ready for the Scythe.

But if there is any Danger, occasioned by a severe Drought, lest the Grass should wither before it be ripe, or be stinted in its Growth, in this Case the Husbandman is wont, in those Places where there is a Possibility of doing it, to water his Meadows; which he effects by letting the Water in upon them by Sluices from the adjoining River, or by turning some little Rivulet out of its natural Course, and forcing it into an artificial Canal, made on purpose to receive it, the Banks of which are raised higher than the Level on each Side, that the Water being damm'd up at the End of the Canal may swell above its Brims, and then diffuse itself over the Meadows, pouring forth Moisture and Refreshment upon the thirsty Grass. In some Parts of the Country every one succeeds in his Turn to the Right of the Water, who after having employed it in this Manner for his own Use, during the Space of half an Hour, or perhaps an Hour, he is obliged to shut up his Sluice or Drain, that it may pass on to serve in like manner for the Benefit of his Neighbour. In the Provinces of *Valencia* and *Andalusia*, they keep their Meadows from being parched up by the excessive Heats they are so subject to in those Places, by means of Trenches, by which every Man draws a Communication berwixt his own Land and the adjacent River; and when the Water

happens to be lower than the Surface of their Meadows, they disperse it upon them with Scoops and hollow Shovels out of the Trenches, insomuch that the River *Xucar*, after being laded out in this Manner for the Space of twelve or fifteen Leagues, becomes drained almost dry.

When the Hay is mowed down they often turn and spread it about upon the Ground, that those hot and saline Juices that are in it may exhale and evaporate, which would otherwise ferment in the Stack, and set Fire to it; in the Night-time they put it up in Cocks, the better to defend it from the cold Dews; and thus they manage it three or four Days before they take it away: However, they are always prepared for any sudden Alterations of the Weather, and ready with their Carts to carry it off in case of Necessity; for it sometimes happens that an unforeseen Storm, or Inundation of the River, does deprive us all at once of so necessary a Part of Provision, either by scattering it abroad over the Face of the Country, or by sweeping it down the Torrent to enrich the Inhabitants of some neighbouring Village with a Booty which the true Proprietors cannot know again, nor consequently recover.

When any one is desirous to reap a second Crop from his Meadow, which we call After-Grass, he must be sure to keep his Cattle out of it till after the Time of cutting it down, which is about the middle of *September*. In your very large Meadows which are held under Lords of Manors, it is usual to mark out so much as is designed for After-Grass, and to leave the rest in common, during the Summer and Autumn, for the Benefit of the Tenants.

Let us now take a further View of the Benefits we may receive from Meadows; and among these the most excellent, as perhaps the most profitable, will be found to be that of breeding Horses, either for carrying or drawing.

There is no Kind of Horses, however contemptible in Appearance, but what is fit for some necessary Use, nay much fitter for the Purpose they are designed, than others that are far more beautiful: For Example; the short, thick-set, full-chested Horse, would soon foil the most fiery well-shaped Steed at drawing in the Plough, the Mill, or any such other hard-working Machine: On the other

The Breeding of Horses.

other hand, the Horse that has a small Head, is high and thin-chested, of a well-turn'd Shape, with a Belly somewhat round and tight, and thin legg'd, is the most proper for Services of a genteel Nature, will do Honour to his Rider in performing Feats of Chivalry, will excel in the Chace or Course, will be serviceable in travelling, or in pursuit of the Enemy.

The different Occasions of Mankind requiring Horses of different Kinds and Makes, Nature, who is ever intent upon making Provision for our Wants, has so diversified the Qualities of Pasture-Grounds, that in some you will find Horses completely beautiful, fit for Persons of Distinction, and more noble Uses; in others, you have those of a middle Sort, fit only for common Labour and Service; and in others, those of the most ordinary Kind, and such as are only proper for Drudgery and the meanest Sort of Work.

Your rich and fertile Pastures, such are those of *Denmark*, *Frizeland*, and *North-Holland*, produce your large Dray-Horses, and such of them as are of a better Shape and Gait than ordinary do not ill become a Coach; others of them are sometimes taken into a Set with other Horses to animate and encourage them, they being so stout and strong in the Hough, that two of them are able to support the prodigious Weight of a publick Voiture * in a Descent. Your Pastures that are not quite so rich, and whose Growth is naturally shorter, and of a more delicious Taste; such as those in the Provinces of *Alençon*, *Tourain*, *Xaintonge*, *Maine*, and *Limosin*, furnish the King's Stables, and those of Persons of Quality, with fine Horses, both for the Harness and for Managing. Your Soil that is of a middle Kind, neither fat nor poor, of which Kind are the Pastures of *Soissonois*, *Franch-Comté*, *High Poitou* and *Bresse*, affords Horses for the King's Cavalry, and such as are proper for Burdens, or to draw in Carriages. *Denmark*, as it sends us fine sizeable Coach-Horses, so is it also famous for those of the smallest Breed, which young Noblemen generally ride upon, or have pretty little Sets of them for their Coaches. The most valuable Saddle-Horses are the *English* Geldings, *Spanish* Gennets, *Turkish*, *Barbary* and *Arabian* Horses.

* A Sort of Vehicle used abroad something like our Stage-Coach.

Oxen.

A second Benefit that we receive from Pastures and Meadows, is that of breeding up young Oxen; which at the Age of three or four Years are put to draw in Teams, and at ten Years old are taken off in order to be fatted. The Age of young Oxen is known, like that of young Horses, by inspecting their Teeth; for at a certain Age they shed their first Set, which gives Place to new succeeding ones; now the second Teeth growing up regularly, one after another, they shew the Number of Years they are old, till the Row being all complete and even, the Mark is out of their Mouths.

The young Ox being naturally a little wild and unruly, must be * early trained up to the Yoke; and as this must be done by degrees, he cannot be too much accustomed at first to be handled, and to receive his Food from his Master's Hand, to suffer his Neck to be encircled with a Willow Twig, or his Horns to be twisted round with a Wreath of Straw; this will prove a Sort of easy Apprenticeship, will make him gentle, and dispose him for the Yoke: The next Step is to couple him with another Ox that has been already disciplin'd, and to make him draw a single Plank, to use him to the Noise of a little Pair of Wheels, and then to increase his Load, till by degrees he at last becomes inured to Labour, and to offer his Neck to the Yoke of his own Accord.

The Profit which the Ox gives to his Owner is very considerable; for after having drawn in Carriages or the Plough for the Space of six Years, he is discharged from Labour, and turned into the Meadows, where he gets Flesh, and comes to be worth two or three hundred † Livres; then he is exposed to Sale among the large-sized Oxen that come from *Flanders*, *Auvergne*, or *Low Normandy*, which every Week stock the Markets of *Seaux* and *Poissy*, which supply *Paris* and the chief Part of *France*. The very Hide of one of these Oxen, after it has gone through the Tanner's Hands, will sell for twenty or five and twenty Livres, and often for a great deal more.

* Tu quos ad studium atque ad usum formabis agrestem, Jam vitulos hortare, &c. *Virg. Georg. 3.*

† A French Livre is about One Shilling English.

The third Advantage we receive from the Meadows, and that of most general Use, is the keeping of Cows; and here the Subject, as Cows. well as Order, does naturally lead me to say something of the Dairy, which I shall do in general, without entering into any particular Account of it. We are so used to leave the Management of all Country-Affairs to mean, illiterate People, that we are apt to frame very disadvantageous Opinions of the Nature of their Employment; we think it beneath us, and, in some measure, disgraceful to us, to be concerned in the Business of a Farm, or to have any thing to do with such vulgar Attainments, and so unworthy the Care of Gentlefolks; but it is an Argument of a Judgment corrupted by Prejudice of Education, to slight that which Nature made the Employment of the first of the human Race, which all Nations have looked upon as the most beneficial to Society, and which, next to Bread, is the Staff and Support of Mankind.

In the main, there is nothing in a Dairy that can offend the Eyes of the The Dairy. nicest Spectator: The Vessels used therein are indeed plain, being seldom or never made of any other Materials than Earth or Wood, but every thing is kept in the most perfect Order and Decency; for Cleanliness is so necessary to a Dairy, that without it, it can scarce be profitable.

Chevalier. When we return from Walking, if you please, we will make a Visit to a Dairy-House, and see the Oeconomy of it; for I have but a very imperfect Notion of it.

Prior. With all my Heart; for the Neatness of the Place itself is not more inviting than the Work which is done in it is entertaining, and which may be made the Subject of a reasonable Curiosity. We have Princesses, no less famous for the Justness and Elegance of their Taste, than for their eminent Rank and Birth, who are so far from despising all rural Employments of this Kind, that they have Dairies of their own, where they busy themselves in skimming the Milk, in pouring the Cream into the Churn, and in churning the Butter: Or else in putting
the

the Rennet * into the Milk to make it turn, in putting the Curd into the Press, and salting it up when the Whey it drained clear from it: Sure then we need not be ashamed to make that our Study, which Royal Hands do not disdain to make their Work.

Chevalier. Pray what Cheese do you reckon the most valuable?

Prior. Every Country has its peculiar Places famous for this Commodity. *England*, for Example, sets most by their *Cheeshire* Cheese; *Hainault* holds that of *Marolles* in greatest Esteem: *Picardy* that of *Guise*; *Normandy* that of *Neufchâtel*, *Pont l'Evêque*, and *Livarrot*; *Dauphiny* that of

Sassenage; *Switzerland* that of *Gruyeres*,
 Cheese. which is prepared with great Nicety and
 Care; and lastly, the *Milanese* send to al-

most all Parts the Cheese of *Lodi*, which we call *Parmesan*, by reason that a Princess of *Parma*, as the Story goes, first brought it into *France*, where it still keeps up its Character.

All these sorts of Cheese are entirely made of Cows-Milk, without any Mixture of Goats-Milk; in these the Cream goes along with the Milk, which is not the Case in common Cheese, which they make only of skimmed Milk, the Cream of which they make Butter of. The Cheese of *Rochfort* in *Languedoc* is noted for being made of Ewes-Milk.

Chevalier. The Profit which is made of these Creatures must needs be very considerable, seeing, generally speaking, they are the only Possessions the Country People have.

Prior. We may make an Estimate of the Profit arising from these numerous Herds which almost cover our Meadows, by that which a single Cow of ordinary Goodness, and up-

The Profit of a
 single Cow.

* Rennet is a sort of Leaven which chiefly consists of that turn'd Milk which is found in the Maw or first Stomach of a Calf, which they salt and keep by them: This, when mix'd with Milk, unfolds its volatile Salts, and by means of the Elasticity of the Air darts them, as it were, in all Directions, into the Milk: This occasions a Motion in the finest Particles of the Fluid, which separates the Serum from the more consistent Parts; these latter associate themselves together in small Globules, which we call Curds, and of which the common Sort of Cheese is made: The better Sort of Cheese is made of the Cream and Milk thus curdled together.

on common Feeding, will yield. A good Cow will give, one Week with another, a sufficient Quantity of Cream to make about five Pounds of Butter. Others that are not so hearty, or under Age, will give about three or four, sometimes not so much. Now to take it at a middle Ratio, and to make Allowance for Abatements in the Winter-time, we will set every Cow at three Pounds *per* Week: We will further cut off ten Weeks from the two and fifty which compose the Year; because that a Cow, during the Time of calving and suckling her Calf, which is thereabouts, spares us no Milk: There remain then, according to this Way of reckoning, forty-two Weeks: But that our Computation may be the more unexceptionable, we Butter. will say but forty Weeks. A Pound of Butter, at some Seasons, will fetch twelve * Sous or more, and never less than five; we will fix it upon an Average at six Sous the Year round, which is undeniably below the true Value of it, not only in and about *Paris*, where the Consumption is great, but almost every where: Three Pounds then, according to this Calculation, will bring in eighteen Sous, or about nine Pence *per* Week. Now where the Produce of Butter is three Pounds; the Quantity of Cheese which is made of the skimmed Milk, is double, tho' it generally yields but half the Price, that is, nine Sous; which added to eighteen, makes twenty-seven; we will, however, rate the Week's Profit arising from both these Articles but at twenty-five Sous, which being multiply'd by forty, amounts to fifty † Livres a Year. I have not here reckoned the Value of the Calf, tho' the smallest of them will fetch five or six Livres; nor have I considered the other Advantages which the Family daily receives from the Dairy, without any Diminution of the ordinary Profits of it; neither have I taken into the Account the Expence which is saved in Dung to manure the Land, which, if not supplied from the Stables, must have been bought; nor yet the fattening the Hogs with

* Twelve Sous French are about Six-pence English Money.

† About fifty Shillings *English*; but if we take into the Account the Cheapness of all Sorts of Provisions, and their Manner of Living in *France*, we may fairly reckon fifty Shillings there, equal to four Pounds with us.

the Whey, which are so necessary an Article in House-keeping, and the chief Provision of the Family. All these Advantages, which we have not taken into the Account of the neat Profit of a Dairy, will abundantly compensate for the Price of the Cow, supposing it to be bought and not bred upon the Farm; as also for the easy Wages of a Cow-herd: We will still farther deduct from the Product of fifty Livres, which we made the Amount of the neat Profit, ten Livres for renting a Piece of Ground sufficient to produce Hay enough to fodder the Cow during the Winter, or in wet Weather; which being deducted, the clear Gain arising from every Cow to a Farmer who has no Land of his own, nor Farm, will be 40 Livres; and consequently, if he has a Herd of twenty Cows, they will bring him in 800 Livres a Year, all Charges paid. It is true, Accidents may sometimes happen which will sink the Profit; but then there are also sometimes accidental Advantages, or extraordinary Demands, which will raise the Price of his Commodity, and make him Amends on the other hand; nay, the selling a few Calves or Heifers, will at once double his Gains: A fatted Calf a few Months old will fetch, at least, fifteen Livres; and those which are bred by the River *Seine* in *Normandy*, and therefore called River-Calves, seldom fail of fetching 30 or 35 Livres, oftentimes more. One Example will be sufficient to shew that my Calculation is both reasonable and moderate: I know a Village consisting of an hundred Houses, situate on the Skirts of a Meadow, which is the only Riches of the Place, tho' it is a great Way from *Paris*, and distant ten Leagues from those two or three neighbouring Towns which are the chief Marts for their Commodities: In this Place, upon a Meadow of half a League square, the Inhabitants keep eight hundred Cows; which at the Rate of forty Livres a Head, would come to but 32000 Livres in all: But by a middle Computation for several Years together, the Amount of the neat Profit is found to exceed forty thousand Livres.

Chevalier. This is a Degree of Plenty almost to be envied: How happy are the People that live near such fertile Meadows?

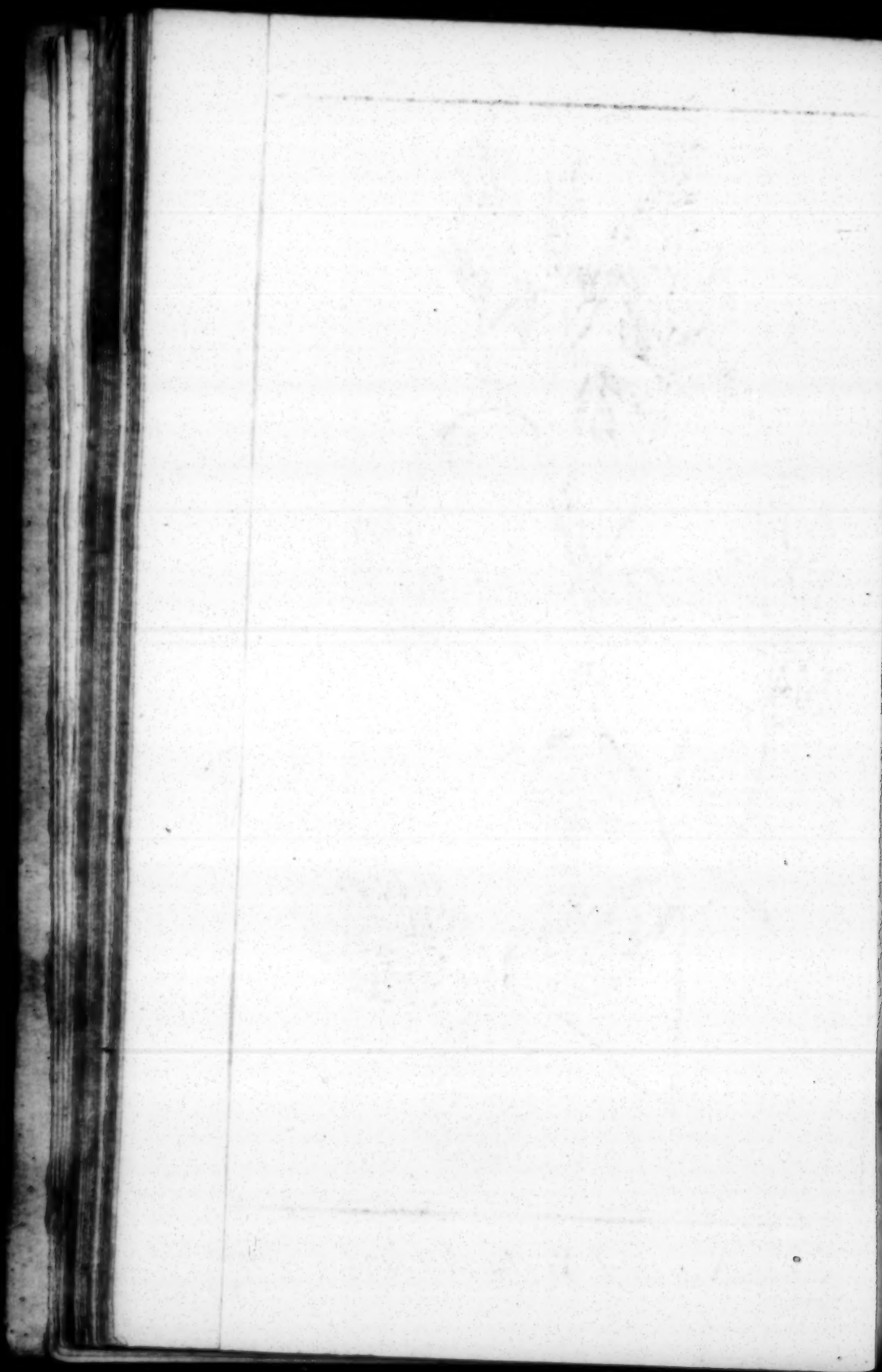
Prior. Their Situation is indeed doubly advantageous; for besides the Benefit of Pasture, it does also yield them
twice



A. Trefoil B. Another kind of Trefoil

C. Lucern

Tome sculp.



twice more Dung to manure their tilled Ground than any other. But neither has God's all-bountiful Providence bestowed its Favours with a niggard Hand on the poorer Sort of Ground, which does not so abound with rich and spacious Meadows; for they enjoy their respective Advantages, and such as are often incompatible with a very fertile Soil. The Fowls it produces are more wholesome and better tasted; the Game more relishing; the Fruits of a more delicious Flavour; and the Bees which feed upon its Flowers, make better Honey, and finer Wax: Besides, what the Inhabitants come short of in Plenty, they make up in good Husbandry, making Advantage of that which in richer Land they slight as useless, and improving every little Hollow, or turfy Bank. As they have no great Crop of Hay, they mix with it Straw, Lentils, Lupins, small Beans, Pease Cods, Vine Leaves, the Husks of all Sorts of Pulse, and even the young Leaves and Buds of certain Trees and Shrubs, as Birch, Broom, Shrub-Trefoil, Sea-Rushes, Elms, and others that I can't at present call to mind. Thus by their Care and Industry they are always provided with that delicious Cream which gratifies the Palate in such sundry Forms and Compositions, and Milk, which is the chief Support of the Poor.

But since it is scarce possible to till and cultivate the Ground without a sufficient Quantity of Grass to feed the Cattle, which are necessary for that Purpose; therefore where Nature has not formed Meadows ready to our Hand, we make, if I may Artificial Meadows. call them so, artificial ones; which is done in this manner: We first of all make

Choice of a Piece of Ground of a proper Extent, which must be ditched round, in order to keep the Cattle out of it; which done, it is plowed and turned over several times; and about *February*, sowed with the best Hay-seed that can be got, or else such as best suits the Nature of the Soil.

If it is of a nutritive good Kind, after it has been worked so as to be sufficiently soft and gentle, it is sown with Lucern, one Bushel of which, or twenty Pounds Weight, is enough to sow a Lucern-Land. hundred square Perches, of eighteen Feet each: But it is customary to mix it with a few Bushels of Oats,

Oats, and to sow them together in Handfuls ; for this makes the Sowing of it not only more easy, but also more profitable ; for the Oats growing fastest, shade the young Grass from the excessive Heats which would otherwise scorch it, and will moreover pay the Tillage of the first Year : The following Years the Farmer cuts Lucern twice or thrice every Year, as it grows into Flower, unless he chuses to let it run to Seed against the third Cutting ; for it is a sort of Seed that sells very well, and the Grass always sheds enough to sow itself again thicker than it was before. It is an Herb of excellent Virtue for young Lambs, which it strengthens greatly, and enables them to bear the nipping Frosts of the Winter : It is good to fatten Horses, which it does in a very short time ; and for Cows, to make them give abundance of Milk ; but they are so greedy of it, that they will often glut and surfeit themselves with it ; so that they are obliged, in order to prevent this, to mix it with cut Straw.

Saintfoin is another excellent Remedy to stock barren Land with Grass, and it is so much the more valuable, as it will thrive in the very poorest Soil : It is sown with Success

in stony, sandy, and chalky Lands, where you scarce meet with half a Foot of entire Earth together : It thrives well upon Mountains, and will turn to good Account, if sown in those Places where Dung is hard to come at ; however, it is not amiss to corroborate the Soil with Soot, which will enrich it with its unctuous and saline Particles ; besides, the Charge of this is small, and the Carriage easy, because a little of it will serve. Let it be noted, that the Proximity of other Herbs is prejudicial to Saintfoin, for which Reason they sow it thicker than other Grain ; six Pounds Weight of it is enough to sow a hundred square Perches of Land. They cut it two or three times a Year.

In the same manner you may sow either Fennigreek, or Esparcet ; but Trefoil is the most profitable, and will also thrive in a poor, ordinary Soil.

Trefoil will stand its Ground four or five Years in a barren Soil : Saintfoin will hold out seven or eight Years in one that is moderately good, and your Lucern will last fifteen or twenty Years in rich Ground. When these
Herbs



Drawn from *life* by M.^r Basseporte

A. The Common Saintfoin. B The Spanish Saintfoin. C The Leaf at the Root of *the* Plant.

Trifolium *scirp.*

Herbs have exhausted all those Salts which are necessary to their Support in the Ground, and begin to languish, there must be a fresh Supply of them, but not sown in the same Place, for they always thrive best in fresh Earth.

Chevalier. How many Ways there are of converting steril Lands into fruitful Meadows! I was in Pain for them, and at the same time that you have found out a Way to enrich them, you have improved my Mind, and given me great Satisfaction.

Prior. Another considerable Advantage we receive from the poorer sort of Lands, by way of Compensation for their Scarcity of Grass, is their affording Pasture for the fleecy Kind. We stand in need of Raiment as well as Nourishment. Now Sheep, which not only feed but cloathe us, never thrive, like the large Cattle, in rich Pastures; over-thick Grass is too hard for them to digest, and does moreover fill them full of Distempers that often prove mortal; besides, there is a muddy, rank Taste in the Herbage produced by strong, moist Lands, that never fails to give them the Rot; whereas they delight more in a dry Soil, and enjoy there a more constant State of Health; the Lavender, the Wild-Thyme, and a hundred other sorts of odoriferous Herbs, give a more delicious and savoury Taste to their Flesh; their Wool is cleaner and finer, and bears a better Price; and their Fat makes a Tallow that vies in Whiteness with the Wax-Candle.

Chevalier. You told me the Profit that might be made of a Cow: Pray what may that of a Sheep come to?

Prior. After repeated Calculations made in different Parts of the Country, it is generally agreed on all Hands, that the Profit of a single Sheep amounts to a Crown a Year, and sometimes more. I will not here trouble you with a particular Account of Gains and Charges, but content myself with giving you the neat Profit of a Sheep: Now this arises chiefly from the Shearing of the Wool, which they do every Year in the Month of May, when there is no more Danger of Sheep-Shearing. cold Weather before it grows again: Of the Locks they cut off, they separate those that grow upon the Breast nearest the Heart from the rest, as being the finest, and this they call the *Prime*; that which is next
to

to it, they call *Second*; and the Remainder, *Tierce*: all that which is grown yellow, or any ways damaged, they set apart by itself, and this

Wool.

goes to make the coarsest and most ordinary sorts of Stuffs. The *Prime* of *Segovia* is undoubtedly allowed to be the most perfect of its Kind; tho' all *Spanish* Wool in general is highly esteemed. The *English*, by having banished all Wolves out of their Island, and stocking it with plenty of Sheep from *Castile*, (which they keep exposed to the Air as much as possible, even in Seasons of severe Frost and Snow, in order to make their Fleeces more soft and tender) have arrived to that Perfection in Wool, as to have it near as good as that of *Spain*.

We have many different sorts of Wool in *France*, and tho' it be far inferior to that of *Spain* and *England*, yet our Manufacturers do so judiciously mix them together, and with that of our two neighbouring Nations, as to make Cloth for all Uses and Purposes, as good as can be wished. Nor do we only not stand in need of being obliged to others for woollen and filken Commodities, but we send of them of our own Manufacture into *Portugal*, *Italy*, the Islands of the *Archipelago*, and all the Sea-Ports * of the *Levant*; where they are held in greater Repute than ever, by Reason of the great Care and Vigilance of our Superintendants, who, by very severe Penalties, guard against any Diminution of them, either in Quality or Quantity. Our Woolens would sell still better, and employ a much greater Number of Hands, if in many of our Dresses we would prefer the plain substantial Taste of our own Stuffs, to the gaudy Lustre of *Indian* Callicoes, &c. the Wear of which must necessarily prejudice the Sale and Manufacture of our woollen Cloth.

There are still other Animals of a tame and gentle Nature that delight to go in Companies, and to live under the Protection of Man, and which bring him in daily Profit even in

Goats.

* The Ports which lie to the East of the *Mediterranean* Sea go by this Name: Here the *Europeans* carry on a Traffick, and keep Consuls, who are the Persons invested with Authority to make Regulations, and determine Differences between the Merchants of their respective Countries.

the most unfruitful Lands : Of this sort are your Goats, which the Owners only need turn loose upon the steepest Mountains or barren Rocks, and by an unconceivable and providential Provision they will return home richly laden with Milk, their Udders dragging upon the Ground, and almost weighing them down with the Burden of it, which is generally enough to suckle two Kids. They give of their Milk to Lambs, when the Ewes have not a Sufficiency for them ; and it also serves to supply the Place of Cows-Milk where they cannot get it ; nay, in the poorer sort of Families, the She-goats, upon Occasion, perform the Office of a Nurse, and give Suck to Children, holding out their Teats to them with a seeming Tenderness and Affection. In many Countries, especially in *Barbary* and *Asiatick Turkey*, about *Angoura* *, their Goats-Hair is so very fine and beautiful, that they spin it for Cloaths, make it into Camlets and other Stuffs, which will bear a Gloss like Silk. Goats Skins are also valuable, and when well dressed and worked, will look like shamoy Leather : And as for the Flesh of young Kids, it is, in many Countries, comparable to that of Lambs.

Another Article of Advantage arising from all sorts of Land, is the bringing up of Hogs. This is an Animal that lives upon Bran, Hogs. Acorns, Mast, all the most useless sort of Grains, Whey, and the Refuse and Trash of almost every Thing : As this Creature is only designed for our eating, Nature has given it a very voracious Appetite, insomuch that it is made an Emblem of Gluttony ; but this she has ordered on purpose that it may fatten the sooner, having so formed and constitutioned its Body, as to make it, by a quick Digestion, convert the vilest Nourishment into the most delicious Substance of Fat and Lean : Nor has Nature less shewn her beneficent Intention in the extreme Fecundity of the Sow, which brings forth Pigs four or five times in a Year †, sometimes fifteen or sixteen at a Litter. The easy Expence of keeping so fruitful an Animal is of vast Service in victualling the poor Country-People, as well as Mariners ; I say nothing of those Delicacies with which it supplies the Tables of the Wealthy.

* This was the ancient *Ancyra* of *Galatia*.

† The Sow goes with Young nine Weeks and odd Days.

Chevalier. I find then, Sir, that every Soil is productive of something, and has its particular Advantages.

Prior. This is a Truth which carries in it Demonstration to the very Senses, that Lands of all Kinds, rich and poor, dry and moist, stony and clay, from the Banks of the River to the Tops of the Mountains, are all covered with proper Provision for those numberless tame Animals that feed upon them, and which, as they are placed under our Care, so are they designed for our Use and Convenience. Let us not then complain of the Scarcity of Meadows in any particular Place, seeing the whole Earth may be considered as one vast Meadow, on which all these Animals feed, and which is only diversified, that it may the better administer to our different Occasions and Delights, by supporting that Variety of Creatures which are necessary to this Purpose.

But besides those Herds and Flocks of Animals, whose Serviceableness to Man I have briefly set forth; that he might be destitute of nothing that could any ways contribute to the Comfort of Life, Nature has

Hens.

further provided several others for his Use. The Poultry, that live upon the Crumbs of his Table, and the Sweepings of his Barn, afford him

Pigeons.

Geese and Ducks.

many wholesome and delicious Meals; the Pigeons requite his Pains and Care of them with the monthly Tribute of their young ones; the Ducks and Geese soften his Bed with their Down, and only require the easy Convenience of a Pond, wherein to sport and dabble, and to find a safe Retreat from the Pursuit of their Enemies; and thus provided, they subsist by their own Industry, till they are taken in to be fatted for their Master's Table.

Swans.

As for Swans, they are not so good for the Spit, (tho' there are some who assure us, that the young ones are very good Meat) as for clearing the Canals, which are so ornamental to a Seat, of those aquatic Herbs and Weeds that grow in them, and which are the chief of their Food.

The Art of Husbandry, Tom. I.

Turkeys, and even Partridges and Pheasants, after they are tamed and brought up by Hand, will go together by Companies

Companies into the Fields, in quest of such loose Grains of Corn as have dropp'd from the Ears, or been scattered by any other means ; and this they do regularly and in Order, after the Harvest is got in, leaving the Farmer's Yard, and going from one Field to another under the Conduct of any young Child : Thus do they feed all Autumn at little or no Expence, till they are in proper Condition to feed their Keepers.

Another Advantage that may be received from the most barren and even most Northern Countries, such as *Lithuania* and *Muscovy*, is the keeping of Bees ; and altho' these Animals do suf- Bees.
ficiently secure to Man the Fruit of their Labour, by that admirable Form of Government and Polity which they observe among themselves, yet they are so form'd by Nature to serve him where-ever he shall think fit to employ them, as to be subject to his Directions, and to fly obedient to his Call, in as orderly a Manner as Sheep obey the Voice of their Shepherd. The Herds-man is no sooner risen with the Sun, but he winds his Horn ; upon which the Horses, Mules, Asses, Oxen, Goats or Heifers, do immediately come forth from their Stalls ; he then advances at the Head of them, and leads them, obsequious to their Guide, into such Pastures as he thinks most proper. With a second Signal he leads them to Water, and with a third reconducts them Home, where every one repairs to his own proper Stall. In like manner the Master of the Hives, with a Blast of his Whistle, can call all the Bees of the Village after him, conducting them by this means, sometimes into one Field of Flowers, sometimes into another ; thus taking them in their Turns, on purpose to give the Flowers Time to recruit their Stock of Sweets, and thereby afford the Bees a fresh Repast. With another Blast of his Whistle he leads them back to their Hives, when either impending Rains, or the Approach of Night, gives Warning to sound a Retreat.

Chevalier. I can't easily conceive how it is possible for Bees to be brought under such regular Discipline.

Prior. This was a very common as well as antient Practice in the East, and to this the Prophet *Isaiah* alludes, when comparing the Armies which God brings upon any Nation

Nation to afflict it, to a Swarm of Bees which a Shepherd calls or dismisses by a Signal given, he says, *The Lord shall hiss for the Fly that is in the uttermost Part of the Rivers of Egypt, and for the Bee that is in the Land of Assyria.* This Custom did still subsist in *Asia*, in the IVth and Vth Centuries, and St. Cyril speaks of it as a Thing very common in his Time, and which he had very often seen *.

Lastly, Silk-Worms are another Species of Animals that will live together in great Numbers, and yield vast Profit even in the most unfruitful Countries. As for the Worms, they are reared within Doors; but the chief Difficulty is in bringing the white Mulberry-Trees to thrive, which they feed upon; and these are preferable to the common black Mulberries, forasmuch as they convert into a finer sort of Silk. We need not any other Encouragement to plant white Mulberry-Trees in our poorer sort of Land, than the great Success they have had with them in our most dry and barren Provinces, such as *Provence*, *Dauphiny*, and others; nor can this be ascribed to the Heat of those Parts, seeing *Dauphiny* is no hot Country; and *Savoy*, where these Trees come to the greatest Perfection, is still colder. It must be allowed that any Enterprize of Consequence ought not to be entered upon rashly; but a bold Venture, when directed by Prudence, and authorized by good Examples, seldom fails of Success. The Novelty of any Commodity in a

* In *Isaiam*, c. vii. 18. Πεποιήται τοίνυν ὁ λόγος, ὡς ἐν μεταφορᾷ τῆς μελισσοκόμων ἱμπειρίας, δι' οὐρίσμασι τὰς μυίας ἀποφέρουσι τε τῶν σίμβλων εἰς ἀγροὺς, καὶ πάλιν ἀνακομίζουσι. This Expression (of *Isaiab*) is figurative, being a Metaphor borrowed from a Custom among the Managers of Bees, who only with a Whistle lead them out of their Hives into the Fields, and in like manner conduct them back again. And upon those other Words of *Isaiab*, v. 26. *The Lord shall whistle them from the Extremities of the Earth*, St. Cyril has the following Remark: Δίχεται δὲ καὶ τὸτο πάλιν ὡς ἀπὸ γῆς τῆς συνθείας τῆς ἐπὶ τῶν μυιῶν· ἐν ἔθει γὰρ πῶς ἐστὶ τοῖς μελισσοκόμοις οὐρίζειν αὐταῖς, οὕτω τε τῶν σίμβλων ἀποφέρειν εἰς ἀνθή καὶ πῶς, καὶ μὲν καὶ ἀνακομίζειν ἐξ ἀγρῶν, οἶκον τε αὐτὰς ἐναυλιζεσθαι ποιεῖν. *Isaiab* takes this Form of Speech from the Manner of managing Bees: For those who have the Care of them, accustom them to know the Sound of the Whistle, by which they entice them from their Hives into the flowery Meadows and Fields, and by the same Signal, summon them home to their Hives.

Country ought to be considered as no material Objection to the Importation of it, as I will make appear by the two following Instances: When the *Greek Monks*, in the Time of the Emperor *Justinian*, had brought the Eggs of Silk-Worms from the farther Part of *Asia* into *Greece*, it was generally said, that the Country of the * *Seres* was too remote from them, to hope that the Silk-Worms could find proper Nourishment and Warmth in so different a Climate; but notwithstanding this Supposition, the Isles of *Greece* and *Italy* became, by Degrees, well stocked with them. When *Henry II.* undertook to plant white Mulberry-Trees in *France*, and to establish Silk Manufactures at *Lyons* and *Tours*, the People seemed amazed, and said with one common Voice, What will all these fruitless and chimerical Projects come to? For so long as Silk-Worms have been known in *Europe*, they were never so much as seen yet in *France*! Nevertheless the *French* Silk Manufactures were then established, and have ever since been carried on with great Success and Credit. Our Mulberry-Trees have greatly increased in a very short time, and in those Places where the Soil turned to very little Advantage before; the Silks which are produced from them is exquisitely fine and beautiful, and is manufactured to as great Perfection at *Lyons* as at *Naples*, or in any Part of the East, and could we but once bring ourselves to make this our common Wear more than we do, the *Indian* and foreign Silks and Stuffs would soon grow out of Favour with us; we might equally gratify our Taste for Finery and Gaiety; and, by thus promoting the Consumption of the natural Produce and Manufacture of our own Country, save that immense Wealth which is carried to enrich the Kingdoms of *Asia* in Exchange for their superfluous Commodities.

* A Country of antient Scythia, famous for producing great Quantities of Silk, from whence it took its Latin Name *Sericum*.

R I V E R S.

D I A L O G U E XVIII.

The PRIOR *and* CHEVALIER.

Chevalier. **I**F the Prospect of the River is an Ornament to the Castle, we must also allow that the Sight of the Castle, thus standing upon the rising of the Hill, is a great Embellishment to the River.

Prior. We have insensibly wandered into the very Place where it forms the most delightful Scene ; as we are here therefore, let us sit down under this Row of Poplars which adorn its Banks, and enjoy the Prospect of that natural Canal with which it presents us.

How delightful an Object is here ! How graceful an Appearance does the Course of a River make in the Works of Nature ! Whether I fix my Attention on the Motion of its Waters, or consider the Advantages it affords us, or endeavour to trace it to its Source ; its gentle gliding in beautiful Meanders ravishes me with Pleasure ; the Multitude of Comforts and Conveniencies it brings us, fills my Soul with Gratitude to the great Author of this, and all other Blessings ; and the Obscurity of its Original does wonderfully excite my Curiosity.

Let us consider it in the several Steps
 The Course of of its Progress and Growth. At first it is
 Rivers. no more than a Vein of Water streaming
 from some Hill upon a Bed of Sand or Clay ; the very
 Pebbles which lie scattered up and down are strong enough
 to interrupt its Course, through which it turns, and winds,
 and murmurs as it goes ; having thus by Degrees cleared
 its way, it unites with other kindred Streams, and with
 accelerated Force rushes impetuous on the Plains below ;
 the

the Violence of its Fall hollows the Ground, casting up the Earth on each Side by way of Banks; thus it pursues its Course, eating a Passage through every thing that opposes it, and digging a Channel for itself. The Overflowing of Ponds, the melted Snow that falls from the Hills, and the tributary Supplies of many Brooks and Rivulets that fall into it, swell it into a large River, and dignify it with a Name. Thus fortified and enlarged, it proudly steers its Course along the Sides of spacious Meads and verdant Fields; it makes the Tour of Hills and Mountains, and in wanton Meanders at once enriches and adorns the wide-extended Plains.

It is a Rendezvous of almost all Sorts of Animals: A thousand Birds of all Colours and Notes take their Pastime upon its sandy Banks, sport and play upon its Surface, or dive in quest of the finny Breed, nor quit the varied Scene till approaching Night hangs out her sable Curtain, and invites to Rest.

The Evening-Star has no sooner shut up the Gates of Day, and the Fowls returned to their respective Lodgings, than the wild Beasts of the Forest succeed in their Turn to the Benefit of the River, which they enjoy unmolested till Morning appears, when they retire into the Woods for Safety, leaving the Plains to Man, and the free Use of the River to the Cattle, which quit their Pastures twice a Day to pay their accustomed Visits to the friendly Stream, wherein they slake their Thirst, or seek a cool Retreat. Nor is Man less delighted with the Beauty and Advantages of the River than other Creatures, seeing for it he flights the Mountains and Woods to fix his Habitation upon its Banks.

After having thus continued its Course through many rural Scenes, distributing its Favours as it passed along; after having enriched the Fishermen with Plenty of Fish, rejoiced the Farmer's Heart by refreshing his thirsty Plains, adorned the Villas of the Wealthy with beautiful Prospects, and, in a word, made the Country both rich and delightful, it makes a Visit to those large Towns whose Opulence and Splendor it has so largely contributed to; here it floats on in stately Pride, where Rows of lofty Structures and costly Palaces on each Side grace its Banks, at once adorning and adorned by it.

The perpetual Concourse of People and Carriages that pass over the Bridges that lie across it, the Multitude of Barks and Boats that float upon its Surface, together with that continual Din and confused Noise that is heard all over its Waters, and from one End of its Wharfs to the other, form in the Mind a very lively and pleasing Idea of the great Wealth and Trade of the City : But above all are we delighted, where the Tide flowing in from the Sea presents to our ravished Sight the Vessels of larger Size, whether we behold them coming with full Sail up the River successively, and joyfully proclaiming their safe Arrival with a Discharge of their Cannon, or see them stationed all abreast and at Anchor in the Haven, forming a Forest of Masts, whilst their Flags and Streamers wanton in the Wind.

Let us suspend a little longer our Curiosity of inquiring what Reservoirs, or Stores of Water, can be sufficient to feed so copious a Current, and that is perpetually running ; and content ourselves with admiring the prodigious Abundance and Extent of that which was so scanty and inconsiderable at its first setting out, as we have already shewed, its Passage through whole Provinces, the Continuance of its Stream along Tracts of Land several hundred Leagues in length, and its surprizing Breadth just before it empties itself into the Ocean, itself a little Sea. Such is the *Rhine*, which coming from *Switzerland* passes through *France*, *Germany*, and *Holland*, where its vast Bed of Waters divides itself into four or five Channels, and mixes with the Sea after a Course of above two hundred Leagues. The *Danube* travels five hundred before it discharges itself into the *Black Sea*. The *Niger* waters near eleven hundred Leagues of Lands in the vast, burning, sandy Desarts of *Africa* ; and the River of the *Amazons* in *America*, which is no more than a little Rivulet near *Quito* where it takes its Rise, after a Course of eight hundred Leagues, according to some Travellers, and eleven hundred according to the Account of others, opens itself into the Ocean by an Out-let eighty-four Leagues in reach.

Methinks I see the whole Earth delved and furrowed with such long Channels, and a surprizing Contrivance in the Structure and Formation of its other Parts to facilitate the Course of the Waters that are to run in them. It is observed, that not only in all Continents, but also in the smallest Islands, there are Mountains at different Distances from one another, some higher, some lower, from which there lies a gradual, though sometimes unperceivable, Descent to the Sea. Now the Sources of Rivers are purposely lodged in the Bowels of these Eminencies, that the Waters, by the Height of their Fall, may acquire such a Degree of Acceleration as to be able to impel the preceding Waters with a Force sufficient to surmount any little Risings which may oppose them, through the Inequality of the Earth's Surface.

The Usefulness
of Mountains to
the Course of
Rivers.

Now we cannot suppose that Providence, which never does any thing in vain, after so great an *Apparatus*, and so much Pains in the Formation and Distribution of Rivers, has not answered some End proportionably great and beneficial thereby. And to be convinced of this we need only reflect upon the high Value every Country sets upon the River it is enriched with, and the great Distress those People are in, that want so great a Blessing.

The Usefulness
of Rivers.

The first and chief End that our great Creator proposed hereby, was, doubtless, to supply Man and Beast with one of the most necessary Elements of Life; and such we must allow it to be, whether we consider it as serving the Purpose of common Drink, or to dress our Victuals, or keep our Bodies and Habitations cleanly and wholesome.

Supplying us
with Drink.

Chevalier. But how can the Water of the River, which carries along with it so much Dirt and Filth from the Places it passes through and cleanses, sufficiently clear and purify itself so as to serve the People it afterwards descends to for all these Uses and Purposes?

Prior. It gradually discharges itself of all Impurities of this Kind by leaving them upon its Banks as it passes along,

along, and which are soon dispersed by the Wind, or exhau'd by the Rarefaction of the Sun. But as our Drink from the River will sometimes happen to be muddy and discoloured by a Mixture of heterogeneous Particles, and therefore liable to produce Sediments, which may prove prejudicial to the Health; in such Cases it is customary, by way of Precaution, to let the Water stand a few Days in earthen Vessels, in which time it settles and becomes as clear as Crystal. Several use, upon this Occasion, a Sort of Copper Cisterns with Sand in them, through which by an artificial kind of Filtration, it clarifies sooner, and with equal Safety, provided the Sand it drains through be often washed, and the Vessel well tinned within to secure it from Verdigrease. In those Places where we do not enjoy the Benefit of Rivers, Nature has made us some amends by supplying us with Springs; or if we are destitute of these, we are pretty sure, by digging to a certain Depth in the Earth, to find Well-Water.

Chevalier. Pray which of these three different Sorts of Water do you reckon the best?

Prior. River-Water, especially that of large Rivers, is for the most part more light and wholesome than that which comes from Springs or Wells; this will be illustrated by a familiar Comparison. The constituent Parts of a Fluid, as Water is, may aptly enough be compared to the Grains of Corn, that compose an Heap; now if this Heap be shovelled and turned over upon a Floor full of Dust and Sweepings, or such-like Rubbish, the whole Heap cannot fail to mix and associate with it; whereas if it be stirred and moved about on a clean Floor, it will cleanse itself, the fresh Air will fan and purify it, and dissipate those heterogeneous Particles which before lodged in it. In like manner the Water which issues from low Springs, or is drawn from Wells, having for a long time run through or stagnated upon Beds of Slate, Chalk, Vitriol, Sulphur, or Iron, washes off some minute Parts of some or other of these Strata, which intermixing with the Fluid may prove detrimental to the Health: On the other hand, River-Water, by having steered its Course for a long time in the open Air, through the many Turnings and Windings of its Channel, and therefore kept in perpetual Motion and Agitation, refines and purges
itself

itself from all impure Mixtures : The Rapidity of its Current in the Middle clears its way as it goes, casting up on each Side such Substances as are of a more gross Nature, as Gravel, Mud, and Dirt, and leaving them upon its Shores : As for those Bodies, that are more rare, and lighter than itself, whether of a bituminous or unctuous Nature, they swim upon its Surface, forming a kind of Scum or Froth that is easy to be discerned, and which soon evaporates by the Heat of the Sun. - So that, upon all these Accounts, River-Water is every whit as wholesome, as, after standing a little, it becomes full as clear as the finest Rock-Water.

Chevalier. I cannot then approve of that Advice which has been so often given me at *Paris*, always to use the Water of *Arcueil*, rather than that of the *Seine* ; nor can I think that Complaint better founded, which I have so frequently heard in the Mouths of some People, for want of Spring-Water at *Paris* ; seeing the long Conveyance of it would not only be attended with great Expence, but be intirely useles, as Nature has provided us a River that supplies us with a more wholesome Fluid.

Prior. You remember to have seen, in the Observatory, a sort of Cakes or Crufts, with which the Water of *Arcueil* lines the Inside of the Pipes it passes thro' ; which Crufts do so thicken by Degrees, that in less than the Space of fifty Years they go near to stop up the Passage : Tho' therefore we should grant that this petrifying Quality of the Water does not form in the human Body any such Sediments as may be prejudicial to it ; yet this must be allowed, that it cannot fail of rendering it more hard and heavy than the Water of the *Seine*, which, after being clarified, is found by Experience to be much lighter, and consequently more salutary. The Inhabitants of *Paris* have therefore no Reason to complain of any Hardship on this Account ; or if they do lie under any, it is for want of having the *Seine* Water in greater Plenty in every Part of the Town, and of its being conveyed into every private Family through small Pipes or Tubes. Two Water-Engines, one on the Bridge *de la Tournelle*, the other on *Ponte-Marie*, would effectually answer this Purpose, and not only save the poor People the great Expence they are at in buying Water, but would also supply them

with that great Convenience of having it near at hand in case of Fires. There is no House-keeper but would readily contribute to defray the Charge of such Engines and Aqueducts, for the greater Security of his Mansion; nor any Lodger that would not be glad to purchase such a Convenience at a less Expence than he is now at for the bare Carriage of his Water; nor would the Loss that any publick Companies might sustain thereby, bear any Proportion to the Sum of the Advantage that would accrue to every Particular from so beneficial a Scheme. But I beg Pardon, my dear *Chevalier*, for exceeding the Bounds of my Province; it is not for private Persons to take upon them to direct those who have already displayed so much Skill and Wisdom in the Order and Government of this great City, as to make it at once the Wonder and Delight of all Foreigners, and to extort from them a Confession that they never beheld any thing like, or equal to it. But let us proceed to consider the other Advantages that we receive from Rivers.

Chevalier. Pray, before you go on to enumerate all the Benefits that may be ascribed to Rivers, let me take notice of one Inconvenience they are the Occasion of; which is, their breaking off all Communication betwixt one Place and another; so that very near Neighbours and the dearest Friends are often under the hard Necessity of a long Absence from each other, by reason of that Separation which is caused by the Intervention of a River.

Prior. Boats and Bridges are a sufficient Remedy against this Inconvenience, if it may be called one, tho' a River is so far from being really any Obstacle to the mutual Commerce and Intercourse of different Provinces, that it is, on the contrary, the very Cement of them.

Rivers the Means
of Communication
betwixt one
Country and another.

This same Element, however fluid and fugitive in its Nature, is yet endued with a sufficient Power and Consistency to support a most prodigious Weight.

Look, for Example, at that Barge which now comes sailing up the River, and tell me how you think such a great Bulk of Timber, with all its Load, is sustained by the Water. You know that the specifick Gravity of Wood is less than that of Water; you know likewise that the

the Freight and the Air which are in the Barge, together with the Timber it is made of, do all form a Body of less Weight than that Column of Water whose Place it fills, which is the Reason that the Barge does not subside. The great Convenience therefore that arises to us from hence, is founded on that Proportion, which is betwixt the Weight of Water and that of Wood, which is not only borne up by itself, but also the Burden it is charged with: But how imperfect, how unprofitable, would all our Philosophy prove, if, after having discovered to us this useful Proportion which these two Bodies bear to each other, it did not further lead us to adore the Wisdom and Goodness of our kind Creator, who has so disposed and constituted the Nature of Things, as to make them serve most effectually the Purposes of our Convenience and Advantage? We see that the Water, which is so useful and beneficial to us, does however oftentimes overflow our Plains, and block up our Way; and can we be so ungrateful, as not to acknowledge the Finger of Providence in having provided us Materials so near at hand, to transport ourselves and Goods safely, over an Element otherwise impassable? Let us now make an Estimate of the Serviceableness of the Barge before our Eyes, not only considering it in general, as it may be loaded with Sacks of Corn, Hogheads of Brandy, Pipes of Wine, Pigs of Lead, or any other Commodity, but by making an exact Calculation of the Burden it carries; which we will do by computing the Weight of that Body of Water, which filled the same Place that the Barge is now in Possession of.

Chevalier. I have a strange Curiosity to see how you will proceed in your Arithmetick.

Prior. The Thing is very easy, as thus: After the Barge has taken in all her Lading, I proceed to examine how much Water she draws, that is, how deep she sinks into the Water. Very well. Upon Examination, I find that she draws, we will say, for Example, two Feet of Water from Head to Stern: This done, I divide in my Mind that Body of Water whose Room it now usurps, into cubick Feet; a Cube, you know, is a Body with six Sides, like a Die, all of equal Dimensions: Now the Business is to know how many cubick Feet there are in

that Bulk of Water whose Place is now occupied by the Barge, and how much every cubick Foot weighs; having done this, we shall have the Weight of the whole Burden.

I will suppose then, that the Barge is an hundred and twenty Feet long, and fifteen broad; now an hundred and twenty multiplied by fifteen, give eighteen hundred Feet; but as we supposed the Vessel sunk two Foot in Water, the Sum total of Feet will amount to twice eighteen hundred, or three thousand six hundred Feet, whether of Water or Freight; for we now consider one as filling an equal Space with the other; so that upon the whole, the Pressure of the Barge upon the River, is no greater than the Pressure of that Body of Water whose Place it supplies.

Chevalier. We must next know how much a cubick Foot of Water weighs.

Prior. This is the very Point I was coming to: Now, in order to inform ourselves of this, the following Experiment will suffice: Take a Box a cubick Foot in Dimensions, and fill it with a solid Substance, which together with the Box that contains it, shall weigh sixty-eight or sixty-nine Pounds; now this Box being put into the Water will not subside, but swim; vary the Experiment, and fill the Box with another solid Substance, (that no Interstices or void Space be left) which may make it the Weight of seventy Pounds; and you will find, that being put into the Water it will immediately sink to the Bottom. From whence I gather that a cubick Foot of Water is * equal in Weight to seventy Pounds: If therefore

* This Calculation of our Author is not critically exact: He supposes that the Box weighing sixty-nine Pounds does not sink, but swim upon the Water, and therefore is lighter than the Water: he supposes again, that the Box being made to weigh seventy Pounds, it shall sink; from which he concludes, that the same Bulk of Water is equal in Weight to seventy Pounds; tho' nothing is more certain than that any Body, which, upon being put into any Fluid, subsides therein, is heavier than an equal Bulk of that Fluid; if it be of equal Gravity with the Fluid, it will remain suspended in that Part of it where it is placed (supposing the Fluid to be in a State of Rest) without ascending or descending. So that by his Experiment a cubick Foot of Water does not weigh full seventy Pounds, but comes something short of it. But our Author does not design here a philosophical Exactness, but expresses himself in round Numbers, as the
more

fore we multiply three thousand six hundred cubick Feet of Water, the Dimensions of that Column of Water whose Place is occupied by the Barge, by seventy, the Sum given will be two hundred fifty-two thousand, which is the Number of Pounds that Body of Water weighs, and consequently the Weight of the whole Barge and its Burden taken together.

Chevalier. How, Sir! This Barge then carries a greater Weight than if loaded with four of the largest Bells of *Notre Dame* * at *Paris*. How comes it to move then with so much Ease?

Prior. It is indeed another Matter of Astonishment, that the Water, which supports such a prodigious Weight, should keep it suspended in so exact an Equilibrium, as that a very small Force should be sufficient to determine its Motion this way or that way: Two Men, for Example, in a little Boat fastened to the Barge by a Rope, shall be able with only the Assistance of a Pair of light Oars, if they have the Current on their Side, to drag after them these four great Bells, as you were saying, or two hundred and fifty-two thousand Pound Weight. If, on the other hand, they would carry the Barge up the River against the Stream, a Rope fastened to the Top of the Mast, and drawn by six Horses, and those none of the ablest, along by the Side of the River, will tow up this heavy Load from *Abbeville* to *St. Quintin*, or from *Nantz* to *Paris*. So that a River is so far from being any Hindrance to a free Communication betwixt one Province and another, that it does, in a manner, unite those that are far remote, and brings *Paris* and *Nantz*, *Auvergne* and *Picardy*, into one Neighbourhood.

Chevalier. Pray let us now distribute this two hundred and fifty-two thousand Pounds Weight into Carts, that by comparing one way of Carriage with the other, we may see the different Expence of each.

more easy and familiar Way of Calculation, and more natural to Discourse. And that our Author did not design to state this Experiment to a mathematical Degree of Nicety, appears from Page 45, where he supposes the exact Weight of a cubick Foot of Water to be rather more than 70 Pounds.

* The Church of our Lady, or *St. Mary's*, at *Paris*, is remarkable, among other Curiosities, for the Largeness of its Bells.

Prior. You shall be satisfied immediately; we will figure out our Calculation here upon the Sand. A Load weighing three thousand Pounds is much more than three Horses can draw for any Number of Days together; but we will fix upon this Proportion, in order to make our Account the more easy and expeditious: If then we divide two hundred and fifty-two thousand by three, the Quotient will give eighty-four times three thousand. In order to carry this Load therefore by Land, we should want eighty-four Carts, as many Carters, and two hundred and fifty-two Horses. What a prodigious Expence would here be to carry from *Nantz* to *Paris*, what four Barge-men and six Horses can convey thither by Water at a very inconsiderable Charge!

River-Carriage is so easy and expeditious, that in those Places where Nature has not supplied Men with this Convenience, they will spare no Pains nor Industry to procure it; they will run Ponds and Brooks into one another, collect every little straggling Stream, make Locks, Reservoirs, and Canals, lay Vallies under Water, and dig Passages through Mountains, and all to form the nearest Communication they can with some River, for the better Conveyance of their several Commodities from one Place to another.

The famous Czar, *Peter*, who was always forming great Designs, secured to himself the Conquest of the Countries about *Derbent*, and on the Shores of the *Caspian* Sea on the Side of *Persia*, to fetch from thence the Silks, Cottons, and other valuable Merchandize, which are carried from these Ports in Caravans to *Aleppo*, *Smyrna*, and as far as the Streights of *Constantinople*. His Design was to import into his own Country, by means of those Rivers which discharge themselves into the *Caspian* Sea, all the Merchandize of *Asia*, especially Silks, which are made in great Plenty at *Chirvan*: They were first to be conveyed through the Mouth of the *Volga* to *Astracan*, from thence, by a Channel of Communication, into the River *Don*, which is united by another Channel to the *Occa*, and afterwards to be brought by the River *Mosca* to *Moscow*: After this, by another Conjunction of Rivers, they were to be transported through the *Dwina* into the *White-Sea* at *Archangel*, and last of all, through the Lake *Ladoga*,

Ladoga, which is at the Foot of the Gulph of *Finland*, to his new Town of *Petersburgh*; which, had this Project taken Effect, would, by reason of its Communication with the Ocean through the *Baltick* Sea, and with *Asia*, by the Canals we have been mentioning, have become the most populous and trading Town in the Universe. But the Death of this great Prince put a Stop to the final Accomplishment of his vast Designs. But to leave projected to come to really existing Conveniencies; let us consider with what Success the Inhabitants of the United Provinces have raised one of the most populous and puissant States (for the Bigness of it) in the World, out of a little Tract of Land before covered with Marshes and Morasses.

They have a vast Number of artificial Canals, which they support with great Care and Industry, that serve to drain off and to receive the Waters, which would otherwise overflow all their Lands; these also form themselves into different Routes or Passages, which often serve for a Communication to several large Towns, within the Compass of five or six Leagues. A Citizen of *Rotterdam* may go from home in the Morning, bid good-morrow to his Friend at *Delft*, and the *Hague*, dine at *Leyden*, and sup at *Amsterdam*, or return home the same Evening; and all this, reading or minding his Business in the Boat, with as little Interruption as if he was in his Compting-House, and without that Fatigue and Inconvenience which are almost inevitable in a Land Journey. In the Winter-time, when the Canals are covered with Ice, a Farmer's Wife, with a Basket of Butter and Eggs upon her Head, and her Skates upon her Feet, will skim away to Market in a trice, sell her Provisions, and be at home again with her Family almost as soon as she was missed. Nor does the Ice prevent the Carriage of their most weighty Burdens; for you will find their Canals loaded with Carts and Sledges, and the same Element serving in the double Capacity of Land and Water.

Nor is *France* without her Canals of Communication; those of *Briare* and *Orleans* bring to *Paris* the Riches and Productions of several Provinces, as well as stock the South of *France* with those Cloths, Camlets and

The Canal of
Briare.

Stuffs

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Stuffs that are manufactured at *Abbeville, Amiens, Rheims, Sedan and Lisle*; and also in Return supply the North of *France* with the Oils of *Provence, Muscadine Wines, dried Fruits, Paper, Cutlery Wares, and other mercantile Commodities* from the Southern Provinces.

The uniting the River *Somme* to the *Oyfe*, which it is thought at present can never fail, opens to the *Parisians* all the Magazines of Corn in *Picardy*, and to the People of the Northern Provinces a short Conveyance of their Sea-Coal, Wood, Butter, Copper, and all manner of Spices to *Paris*.

The Communi-
cation betwixt
the two Seas.

But a Work that far excels all that I have mentioned is the Royal Canal of *Languedoc* *.

A Communication betwixt the *Mediterranean* and the Ocean, by means of some artificial Canals uniting the navigable Rivers, and thereby shortening the Transportation of Merchandize, which they used to carry through the Streights, making the Circuit of the Coasts of *Spain* and *Portugal*, was a Convenience always much wished for, but looked upon as impossible to effect, by reason, that betwixt the *Mediterranean* and that Part of the *Garonne* where it begins to be navigable, there was a Length of above forty Leagues of Land, and no other Water than what proceeded from some little Springs and Rivelets; but notwithstanding the immense Distance, the Inequality of the Surface of the Ground, and its rising towards the middle far above the Level of the Sea, Mr. *Riquet*, with great Judgment and Penetration, projected a Plan of a Canal for Vessels to pass from *Toulouse* to the *Mediterranean*, and back again, by Ascents and Descents without any Hindrance. Mr. *Colbert* approved of this Scheme, and found it to be no less practicable than advantageous, and proposed the Execution of it to *Lewis XIV.* The Work was begun in 1666; was resumed, after some Interruption, in 1677; and ever since the Year 1682 has continued to answer the Purposes of Navigation designed by it.

* A Letter to Mr. Barrillon, Toulouse, 1672.
A Visit made to the Royal Canal in 1723.

Chevalier. Pray, Sir, can you give me a Notion of the Formation of this Canal? For my own part, I cannot conceive how such a Channel could be made navigable, seeing Vessels cannot ascend but by the Water, which never rises above its Level.

Prior. The Hill of *Nauroufe*, which is nearer to *Toulouse* than to *Narbonne*, was the Place that seemed most proper from which to draw two Channels or Canals, the one of which was to descend into the River *Garonne*, the other into the *Mediterranean*. Upon this Hill Mr. *Riquet* pitched upon a Place that was elevated six hundred Feet above the Level of the two Seas, and from which he observed, that the Ground lay sloping down on either Side almost in one continued Descent to them:

Here he endeavour'd to make an Assemblage of sufficient Supplies of Water to distribute into the two Channels that were to lead, one to *Toulouse*, the other to the *Mediterranean*.

The Point of the Division of Waters.

There being but one Spring at *Nauroufe*, and that very insufficient for the Purpose, he brought thither from the neighbouring Mountains*, by means of an Aqueduct about five Leagues long, a Current of Water containing, in Breadth and Depth, five or six thousand Inches; which being distributed in the two Canals leading to *Toulouse* and the *Mediterranean*, joined to form a Body of Water, measuring in every Part above a Million of cubick † *Toises*.

In case of Drought, he farther provided

a large Magazine of Water to be dug

near *Nauroufe*, containing above six hun-

dred thousand cubick *Toises*, which was to be kept in Reserve to feed the Source of Distribution in very dry Summers.

The Reservoir.

In those Places where the Land lies upon a Declivity, the Water is confined within large Sluices

or Beds, from twenty-four to thirty Feet

or more in Breadth, hemmed in on each

Side by high Walls that run parallel to each other, with very strong Gates to let the Water in or out; which fall-

The Sluices.

* The Robine, or Canal, for conveying Water from the *Black Mountain* to the Source of Distribution.

† A *Toise* is a Measure about a Fathom.

ing down from the higher into the lower Sluices forms very large and beautiful Cascades, highly delightful to the Eye of the gazing Traveller. Suppose we now a Bark in its Passage from *Narbonne*, after having sailed through the Canal which runs along the Plain, to come to the Foot of one of these Sluices; the Sluice-Gates are immediately flung open, the Water before confined rushes forth, and, mixing with the Water that is without, forms one common Level; the Bark then sails in, and the Gates are shut again; this done, the upper Gates are opened to let in the Water from above, which rises by Degrees, and mounts the Vessel to a Level with the Water in the second Sluice; so that by this means a Vessel coming from *Narbonne* may readily pass out of the first Sluice into the second, or one coming from *Toulouse* out of the second into the first. The Gates of the second Sluice being then shut, the Bark ascends in like manner into the third Sluice; and thus from Sluice to Sluice it gains the Summit where the Canal begins, and is conveyed down the other Canal by the same Sort of Sluices or Locks to *Toulouse*.

Chevalier. You have given me a very clear and distinct Idea of this well-contrived Water-Ladder, if I may be allowed to call it so; but yet methinks I cannot but be surprized at the Boldness of this Undertaking, which, though very beneficial to the Publick, one would think should have deterred the Projectors from the Execution of it upon account of the vast Expence that must necessarily attend it.

Prior. If we except the *Roman* Highways, we shall find no Work of Antiquity surpassing this. This Canal, from the Place where it discharges itself into the Port of *Cette* to *Toulouse*, is above seventy Leagues in Length: Besides, they were often obliged to turn and wind its Channel in order to preserve the Level, to support and strengthen it with Piles where the Earth was apt to give way, to carry it over Bridges and Arches of Stone in the Valleys, to cut Passages for it down the Sides of steep Mountains, or to lay them level with the Ground, to hollow others and arch them over for it to pass through; above two Million of cubick Toises of Earth, and above five thousand of solid Rock, have been dug out in order to
make

make its Bed; a hundred and * four Sluices contrived to make Vessels ascend and descend, sixteen prodigious Banks to turn by those Waters which might any ways incommode their Passage, and twenty-four large Drains to draw off the Water when there is any Danger of the Channel's being choaked up with Sand or Mud. There are computed to be above forty thousand cubick Toises of Masonry in Stone belonging to this Work, besides two Arms of Stone that stretch out into the Sea, consisting of two hundred Toises, and a Pier of five hundred, that guard the Port of *Cette*, and render it a very safe Harbour for Ships; an Advantage the more valuable, as the Coast of *Languedoc* is very dangerous, and quite destitute of Havens. All this may probably appear to you to be a prodigious Expence, yet, notwithstanding, it is almost inconsiderable, if compared to the Advantages that are received from the Serviceableness of this Work to Navigation.

Chevalier. I could not have thought that we had so extraordinary a Work in *France*; sure this alone would have been sufficient to immortalize the Reign of *Lewis XIV.*

Prior. Let us not be over-fond of admiring the Works of Mens Hands; for they can only put in Use those Instruments and Powers which God has given them. We are wrapped up in Praise and Astonishment at beholding a Canal wherein there appear such Marks of Industry and Grandeur; but let us not rob God of the Honour due unto him, whose Hand has formed such vast innumerable Canals from one End of the Earth to the other; and so far ought we to be from looking upon Rivers and Seas as any Interruptions and Hindrances to us in those Places where we live, that it is our Duty gratefully to acknowledge them to be, as they are in Effect, the great High-ways of those Countries they pass through, or as so many publick Vehicles that are always ready to set out with us, and to carry the Traveller with all his heavy Luggage where-ever he pleases. But come, let us pass on to those other Benefits for which we are beholden to Rivers.

* I find in some Accounts a hundred and fourteen Sluices.

42 D I A L O G U E XVIII.

Chevalier. After having supplied us with wholesome Drink, and Conveniencies for Travelling, what farther Benefits can we expect from them?

Prior. It is to them we owe the Cleanliness of our Dwellings, and the Fruitfulness of our Countries.

Our Habitations become unwholsome, either when stagnating Waters breed Damps, or when great Scarcity of Water occasions an excessive Drought; whereas every little Rivulet refreshes the Air of all the adjacent Places with its gentle Dews, and cleanses the Earth of all Filth and Nastiness. The largest Moats that surround Castles, Ponds, and even Lakes in the Bottom of Vallies, cease to be dangerous and unwholsome Neighbours, where a living Stream crosses or feeds them. Nor does the Current of the River act only upon that Body of Water it passes through, but also upon the Air, causing it by its Impulse to disperse those Vapours which are exhaled from the Waters, and which by remaining long in the same Place would prove unwholsome and infectious: By these means the three Rivers that fall down from Mount St. Gotard, and run into Lakes of sixteen or eighteen Leagues in Length, and four or five in Breadth, prevent the settling of those Damps and Fogs that exhale from them, and which would otherwise occasion a total Desertion of the Inhabitants which live upon the Borders of them. In like manner the *Tessin*, which runs across the Lake Major, the *Rhine* that keeps in Agitation the Lake of *Constance*, and the *Rhone* that cuts its rapid way through the Lake of *Geneva*, are the only Cause that purifies the neighbouring Regions of the Air, and what alone secures to the Inhabitants the free Enjoyment of all other Advantages they are possessed of.

The Fruitfulness of Lands is likewise generally owing to the Proximity of Rivers. How amazing the Difference betwixt a Country that is watered by a River, and one that is destitute of this Convenience! The latter is dry, desolate and uninhabited, and sometimes not thought worth the Pains of Cultivation; the chearless Traveller that wanders through it, who, instead of verdant Fields and delightful Objects, sees nothing but a barren Waste; instead

instead of the warbling Melody of Birds, to relieve the Fatigue of his Journey, hears nothing but the Shrieking of famished Grass-hoppers and such like Insects; with weary Steps, and drooping Spirits, sighs and longs for the End of such uncomfortable Desarts. He at length comes to the Top of a Hill which presents him with a quite different Scene: Here his ravished Eyes wander over the varied Beauties of the Vale beneath; the shady Woods, Fields of Corn, spacious Meadows, beautiful Seats, and crowded Villages, form a Prospect no less delightful than new to him, and he thinks himself all on a sudden transported from the Desarts of *Arabia* into the Land of Promise. Now what occasions all this mighty Difference? Nothing but that winding River that runs gliding through the Vale, distributing Plenty and Pleasure where-ever it passes.

Chevalier. I can easily conceive how a River should give a lively Verdure to the Grass of the Meadows, and to the Trees whose Roots it passes by; but how can it confer the same Nourishment upon that which is a quarter of a League, or perhaps a whole League distant from it? And yet we often see Vallies three or four Leagues broad, that by the Help of one River running through them look like a terrestrial Paradise.

Prior. Be pleased to remember, Sir, what I have observed more than once, that Plants receive Nourishment as well from their Leaves as Roots; insomuch that oftentimes when the Earth is almost exhausted of its Humidity, having scarce any left wherewith to feed the Roots, the Dew alone which falls upon the Leaves in the Night-time, being sucked in and distributed through the whole Plant, does supply it with Moisture, as does appear from the * Weight of it being considerably augmented. Now, although the Air is replete with an infinite Number of Particles or little Globules of Water, which in the Day-time are rarefied by the Heat, and lifted up into the higher Regions of the Atmosphere, but condensing by the Cool of the Evening descend to recruit the thirsty Plants, after a long Perspiration of their Juices; yet the River is the principal Magazine that supplies this necessary Expence

* *Vegetable Staticks* by Stephen Hale, Fellow of the R. S.

of Moisture, which exhaling from it in Mists is carried by the Wind to fall down again in refreshing Dews, not only on those Places which border upon the River, but also on such as are several Leagues distant from it. Thus do all the Parts of Nature mutually help and assist each other, declaring themselves, in the wonderful Variety of their Operations, to be all the Handy-work of the same wise Author and Artificer, as they do undeniably demonstrate his kind and providential Regard to our Happiness and Welfare.

Chevalier. We have not yet spoken one Word of the Fish in the Rivers. I expect to hear some curious Particulars concerning them.

Prior. To-morrow I will send all our Fishermen to you, or else you will find them here at the Water-side, when you will see them at their Work, and have an Opportunity to inform yourself of more Particulars on this Head than I can possibly acquaint you with.

RIVERS.

DIALOGUE XIX.

The PRIOR and CHEVALIER.

Chevalier. OUR Fishermen make a tedious Stay.

Prior. Never fear, they will not disappoint you; however, till they come, we will amuse ourselves by considering what other Benefits we reap from the Current of Rivers. Let us take a Turn here by the Side of this Dam, which you see they have cut out of the River.

Chevalier. Pray, to what Purpose have they inclosed this large Bed of Water, which shews like another River?

Prior.

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Prior. When the whole Breadth of the River is more than sufficient for the Situation of a Mill, or when the free Use of the Current is wanted, either for the Purposes of Navigation, or for conveying Floats of Timber down the Stream, in such Cases we content ourselves with a part of it, which is drawn off into a Trench to turn Mills for grinding, fulling, and sawing: So admirably is the Nature of Water constituted to answer all our Occasions, as well by its Fluidity as Force. By the latter it works vast Machines, thereby saving us great Expence and Trouble; by the former it is made to run, to stop, to contract, to dilate, to spring, and to rise to almost whatever Height we please.

The Force of Water is compounded of its Weight and Velocity together.

The Force of Water.

We have already observed, that a cubick Foot of fresh Water weighs about seventy Pounds, or, strictly speaking, rather more; I say fresh Water, because that Sea-Water, by reason of those Salts that are mixed with it, is more weighty, a cubick Foot of Salt-Water being equal to about seventy-three Pounds; which is the Cause why a Vessel coming from the Sea into the Mouth of a River draws more Water, or sinks deeper; for being now passed into a lighter Fluid, it must fill a greater Space below the Surface of it, in order to preserve an Equilibrium.

Let it be observed, that a cubick Foot of Water does not only act upon other Bodies by its Weight, but also according to the Degree of its Motion; for if its Velocity be increased two or three Degrees, it answers the same Purpose as if the Weight of it was increased in the same Proportion.

The Velocity of Water.

Now the Motion of Water may be accelerated either by giving it a Fall, or by contracting its Channel.

Water, like other ponderous Bodies, does acquire by falling different Degrees of Velocity, and those in Proportion to the Height of its Fall. We shall not at present examine into the exact Proportion of its accelerated Force; let it suffice at this time to know that its Velocity is equal to its Weight, and that if the former be increased two or three Degrees, the Impulse or *Momentum* of it will be

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be double or triple to what it was before. This may be exemplified in a great Flake of Ice, which, when carried by an easy and gentle Motion against a Bridge, makes a very slight Impression upon it; but when falling down the Stream with a rapid Motion, will overturn it: In like manner the Water of a River, when in its slowest Motion, will be sufficient to turn one of that Sort of Mill which we sometimes see built upon a Barge, the Flyers

A Barge-Mill.

of which being very large, a greater Column of Water presses upon them, and forces them round, notwithstanding the Slowness of its Motion.

A Dam-Mill.

A Part of the same River, when contracted within an Arch, or let in at a Flood-Gate, will, by its accelerated Force, turn round a large Wheel, the Flyers of which, though very narrow, are so contrived as to dip successively into the Water to receive its Impulse.

A Trough-Mill.

Lastly, A Stream of Water not more than one cubick Foot in Breadth, when collected into a Trough, and falling upon a little Wheel cut into several transverse Gutters or Trays to receive the Water, will turn the Mill-Stone by the Force of its Acceleration, notwithstanding the Inconsiderableness of its Weight; for it is experimentally true, that a Foot of falling Water acts more forcibly than several Feet running parallel to the Horizon; and this Force is still augmented by every Degree of its Fall. If the Wheel was placed exactly on a Level with the Trough through which the Current is conveyed, every Gutter or Tray in the Wheel would only be acted upon by the Weight of one cubick Foot of Water, or seventy Pounds; but the Wheel being placed so much lower than the Trough, that the Water in falling down upon it acquires a threefold Velocity, it is consequently acted upon or impelled by a threefold Force. Thus we see that a Stream of Water of only one cubick Foot will acquire, by means of Acceleration, a moving Force equal to three cubick Feet, or two hundred and ten Pounds; which being continually succeeded by the repeated Action of other two hundred and ten Pounds on the following Trays of the Wheel, is more than sufficient to give a quick Motion

to the Mill-Stone or Mill-Hammers; just as we see a Top, that is whipped by a Child, turn very nimbly round when the Lashes are quick repeated.

Chevalier. The only Difference then, as far as I find, betwixt a Trough-Mill and a Mill with Flyers, is this: That in the former the Water rushes violently down from the Trough upon the Wheel, whereas in the latter, it runs under the Wheel, taking the Flyers with it as it goes along; and this it does in the same manner, whether the Mill be built in a Barge, or be made of Stone like that which we now see.

Prior. You are in the right, Sir. I don't doubt but you would be extremely delighted to view the Structure of this surprizing Machine within; but we will defer our Speculations on the Contrivances and Inventions of the Wit of Man to another Opportunity; and proceed at present to admire the vast Use which the Motion and Force of Rivers is of to him, in grinding his Corn after the most expeditious and cheapest manner, which else must be ground by a great Number of Slaves or Horses, which would want frequently to be relieved, or would faint under such hard Labour.

The same Machine is also used in pounding of Tan with great heavy Pestles, in fulling and cleaning of Stuffs, which are laid in Troughs, and beat with Hammers of a prodigious Weight; in sawing huge massy Pieces of Timber; in working of Rags into a Paste to make Paper of; in refining Iron and Copper with a Hammer of an enormous Size, which does more Work at one Stroke than fifty Men striking all together; in bruising of Olives; in pressing the Juice from the Sugar-Canes; in winding of Silk into Skains, putting in Motion five or six hundred Bobbins at the same Time, and all under the Management of a single Director.

Chevalier. What innumerable Advantages do flow from a River! But pray how comes it to pass then, that we so often hear People complain that their Estates lie on the Side of a River? And whence that common Proverb, that a River is a bad Neighbour?

Prior. It must be confessed that this great Force of Water is not sometimes without its mischievous Effects: For Example, when the Current of a River makes Head
directly

directly against a Bank that opposes its free Course, and alters its Direction, the Water with seeming Fury and Resentment levels all its Force against it; it undermines it, it hollows it, and if it does not eat its Way through it, it wastes away the Extremities of it, carrying every now and then a Bit down its Channel: Nay, sometimes it washes away large Pieces of Earth, forces its Way into the Meadows, and confounds Boundaries and Land-Marks. Now it is the Nature of Water, where it hollows itself a new Bed on one Side, to abandon as much Ground on the opposite Side: Hence the injured Landlord, who suffers this Incroachment from an Enemy that insensibly purloins away his Property, without having it in his Power to procure Reparation for the Wrong, laments and bemoans his hard Fate, but all in vain; whilst he on the opposite Side of the River rejoices at his good Fortune, and thanks his lucky Stars for an

Alluvion.

Alluvion, or Increase of Land, that costs him neither Trouble nor Expence.

Now it is the Contrivance and Industry of Man only that can prevent these Inconveniencies, or apply a Remedy where they do happen. Accordingly it is customary, in order to prevent the Incroachments of Rivers, to fortify the Banks with

Linings.

a good Lining of Fascines, or rather of strong Planks fastened to the Shore with stout Piles.

A thick Wall built in an oblique Direction to the Current of the River is the surest Way to break the Force of the Stream, and to prevent the falling in of the Ground; but as this will require an Expence that can only be borne by those that are very rich, it is a

Buttresses.

common Practice among the Proprietors of Land to make a Buttress of Wood strengthened with Earth serve their Turn; or else a

Dikes.

Dike of Stones and Rubbish cast up for the Water to spend its Fury upon; for these are

easily repaired, and answer the Purpose of a Wall.

By like Industry they insure to themselves the Possession of Alluvions, or such Land as is left by the Water. When the River recedes from one Shore, the next Owner, if he has a mind to prevent the Return of it to the same Spot, and to make Advantage by it, will be sure to raise

a Dike

a Dike with Stakes or Willows, or rather cast up a high Mole, securing it with large rough Stones cut out of some neighbouring Quarry; in the vacant Space which lies behind the Dike or Mole he will plant young Osiers, that the Water, as it rises or falls, may insinuate itself through the Interstices of the Stones into the Osier-plot, where the Mud and Slime it carries along with it, settling to the Roots of the Osiers, binds and feeds them; which being thus continually supplied with fresh Soil, will grow and thrive apace, and yield a Crop every three Years, bringing in more than the Interest of the Money laid out upon the Dike.

Chevalier. After explaining to me the Serviceableness that accrues to us from the Force of Water, you promised, Sir, next to shew me how beneficial it proves to us by its * Mobility, or easiness of Motion.

Prior. The Effects produced by this Quality are no less surprizing or advantageous than those before-mentioned. Water waits but the Pleasure of Man to change its former Course, and to enter into whatever Channels he thinks fit to prepare for its Conveyance; it distributes itself into his Gardens or Apartments, through Stone Conduits, through Pipes made of burnt Clay, Elderwood, Iron or Lead; it beautifies and adorns great Towns with delightful Water-works, with full Reservoirs and Basons, either in publick Squares, or the private Gardens of Gentlemen; it rises up into the Houses of Dyers, Brewers, Tanners, Workers of Shells, and of all other Tradesmen; it ascends, obedient to the Sucker, when pumped from the Bottom of Mines and Pits, freeing the Workmen beneath from the Apprehensions of a watery Death; it springs up to the Height of a Mountain, thence falling down again in beautiful Cascades, in Sheets of Water, or in the Form of a Dew; it assumes the Figure of a Sheaf of Corn, or a Theatre; and, in short, like *Frutus*,

* I have been obliged to render *Soupleffe* in the Original by the English Word *Mobility*, which tho' it may not be so exact a Translation of it as could be wished, yet I cannot find any Word in our Language that comes nearer the Sense of it in this Place. *Suppleness*, *Pliantness*, *Flexibility*, &c. are more applicable to solid than fluid Bodies.

puts on a thousand Shapes, according to the Art and Fancy of the Engineer, who knows equally how to employ it, either for Ornament or real Use.

As Vessels are necessary to give Water that Form it is designed to put on, and to receive it in its Fall, so we need make no Question but that Stone, Sheet-Lead, Marble, or Copper, may be indifferently used for both these Purposes; tho' in my Mind, there seems such a natural Relation, such a mutual Harmony and Agreement, betwixt Water and the Verdure of the Ground, as if they were designed for each other; and where-ever any thing gaudy or artificial breaks in upon that rural and agreeable Simplicity that they form together, whether of Columns, Gilding, or a hundred other Ornaments either in cast or carved Work, it seems unnatural and quite foreign to a Garden.

Having now considered those inestimable Advantages we receive from the Current of Rivers, let us turn our Thoughts a little to what they contain, or such of their Productions as are most beneficial to us.

Chevalier. I have often read in the *Latin Poets*, and also in other Authors besides them, Descriptions of Rivers,

Rolling with wealthy Pride o'er Sands of Gold.

I should be glad, Sir, to hear your Opinion of this Matter, that I may know what to think of so extraordinary a Property which they ascribe to a great many Rivers. What! did the River *Phasis* ever produce any Gold? Or, what must we think of *Hermus*, *Pactolus*, and *Tagus*?

Prior. Poets, you know, are allowed to make use of the Figure Hyperbole; and therefore it is no Wonder if they have distributed their Gold among these Rivers somewhat more liberally than Nature has done. However, that there were Rivers formerly that had Gold mix'd with the Sand or Mud which they cast up upon their Shore, is a Fact that needs no other Proof than the Traffick which is carried on at this very Day for the Gold-Dust that is found in some Rivers. This is the only Commodity that enriches the People that live upon the golden Coast of *Guinea*, as also those of the Kingdom of *Sophala*, or
Sophara,

Sophara, which is not improbably conjectured to be the *Sophira*, or * *Ophir* of the Antients. The River *Axem*, and several little Rivulets that discharge themselves into the *Zair*, as also a great many Rivers of the vast Kingdoms of *Sophala*, *Monomotapa*, *Zanguebar*, and *Abyssinia*, have more or less Gold mixed with their Sands, in Proportion to the Quantity of Rain that falls in those Countries, which soaks into the Earth, and drains through the Mines, before it passes into the Rivers, carrying along with it the finest Parts of the Ore.

Nor is the Privilege of rolling down golden Sands confined solely to the Rivers of *Africa*, or those of *Brazil* and *Chili*; for we have several of them in *France*, upon the Banks of which this precious Sand is sometimes gathered. The River *Arriege*, near *Pamiers* and *Mirepoix*, does now and then cast up some Spangles of this Metal; it is also found on the Sides of the *Gardon* and the *Ceze*, which are little Rivers that fall from the Mountains of the *Cevennes*; nor is the *Salat*, that passes through the District of *Pau*, without it; in short, it has been often seen on the Shores of the *Doux*, the *Rhine*, the *Rhone*, and the *Garonne*, most probably in those Places which are near the Conflux of those little Rivers that fall into them from the neighbouring Mountains. Sometimes a Man that makes it his Business to seek for this Dust in the *Arriege* or the *Ceze*, shall make a Pistole of his Day's Work; at other Times, shall think himself well off if he makes 40 Sous †, and some Days he shall get nothing at all. The Country People, who set apart those Hours for Gold-finding that remain from their Day's Labour, and after they have been employed in Work that is more necessary, as well as yielding more certain Profit, chuse the Time of the Fall of the Waters, after a Flood or Inundation of the River; and above all, they look out for that Sand which is distinguished from the rest by the Blackness of its Hue; for this is a certain Mark, that there is some Mineral mixed with it. Sometimes this Sand is cast

Memoirs of Mr.
de Reaumur, 1718.

* The Version of the LXX. call it *Sopbir*. *Origen* upon *Job*, chap. xxi. 24. does the same; and is of Opinion with several other Interpreters, that the County of *Sopbira* is in *Africa*.

† About two Shillings English.

up upon the Sides of the River, sometimes it is found lodged in the Cavities of Rocks, or behind such large Stones as break the Current of the Water; and now and then it is picked from off Pieces of Stuff, or the Fleeces of Sheep, in which it had entangled itself.

Chevalier. Might it not then be some Gold that was found in this manner upon the Shores of the *Phasis* in *Colchos*, that gave Occasion to the Fable of the Golden Fleece?

Prior. The Thing is credible enough; but to the Purpose. After having separated the common Sand and Dirt from that which contains the precious Dust, by frequent Washings; if there be any Grains of a larger Size, distinguishable by the Eye or the Touch, they sever them from the rest, tho' generally they are so very small, that they are obliged to effect this Separation by pouring Mercury upon the Sand, which is endued with this particular Quality, that it attracts to itself all the little Particles of Gold that come in its way; after this they separate the Quick-silver, to which these Particles adhere, from the whole Body of Sand by new Washings, and put it into a little Bag made of shamoy Leather; then by squeezing and pressing the Bag, the Mercury exudes through the Pores of the Leather, and leaves the Gold by itself behind. Those who have made this their chief Study and Employment, have observed, that after the Sand is well washed, it shews itself generally in three different Colours, black, white, and reddish; that the white Sand, when viewed through a Microscope, appears like a Heap of small transparent Crystals; the black, like so many Particles of Iron, several of which will be attracted by a Knife that has been touched by a Load-stone; and that the reddish Sand, when viewed the same way, presents to the Eye a delightful Sight, not unlike that of a Jeweller's Box of Treasure; wherein you see Rubies of a Rose-colour, others of a deeper red, Sapphires, Emeralds, Hyacinths, Topazes, and, in short, transparent Stones of all sorts.

There are likewise Rivers that carry down with their Streams not only such little Stones as, by reason of their excessive Smallness, are quite useless to us; but also such as are of a moderate Size, some of which are vein'd like
Agate,

Agate, some of an Emerald-Green, and others transparent like Crystal, and perhaps of the same Nature. These they cut and polish whereof to make Seals, little Boxes, Ornaments for Buckles, Heads for Canes, and a great many other Toys. The River that descends from the Mountains that are in the Middle of the Island *Ceylon*, does every now and then cast up upon the Plain, Rubies, and other Stones, more clear and beautiful than those that are found in the Mines of *Pegu*.

Chevalier. If these Waters then afford precious Stones, and golden Sands, they must needs have passed under Ground through Mines of the same Nature, some Parts of which, by perpetual Friction, they wear off, and carry along with them. By this Argument then we should have Gold Mines in *France*.

Prior. There have been very fine Veins of this Metal found at *Bouconville* in *Picardy*, and at *Rumigni* in *Champagne*, and others in *Dauphiny*, and elsewhere. It is true, the small Quantity of pure Gold which they have been able to get at their first Attempts of this kind, has discouraged the Undertakers from proceeding in so unprofitable an Enterprize; tho' probably it is with Veins of Gold as with those of Marl, Sea-Coal, Lead, and of other Minerals and Fossils, the first Beginnings of which are, for the most part, very small and inconsiderable; but, if we have Patience to trace them, will oftentimes conduct us to inexhaustible Beds of Treasure; for Nature seldom does Things by Halves, or proves abortive in her Productions. It is above seventeen hundred Years ago since *Diodorus Siculus* remarked, that the *Gauls* were supplied with Gold from their Rivers; and the same have continued ever since to bring us the same Tribute from those never-failing Sources that enrich them. These, one would think, should be looked upon as a sort of publick Advertisements, that have for so many Ages been hinting to us the great Improvements that might be made of this Advantage, and which therefore ought not to be neglected: Besides, if we would take the Pains to dig for Gold, we should either find Marl to manure our Land, Quick-silver so useful in the Separation of Metals, Vitriol and such-like Salts, or some other mineral Bodies that are always useful. We scarce ever dig far into Earth with-

out finding Riches of one kind or another, and sometimes by that means contract Intimacies with Nature, that prove more beneficial to us than those very Mines we are in quest of.

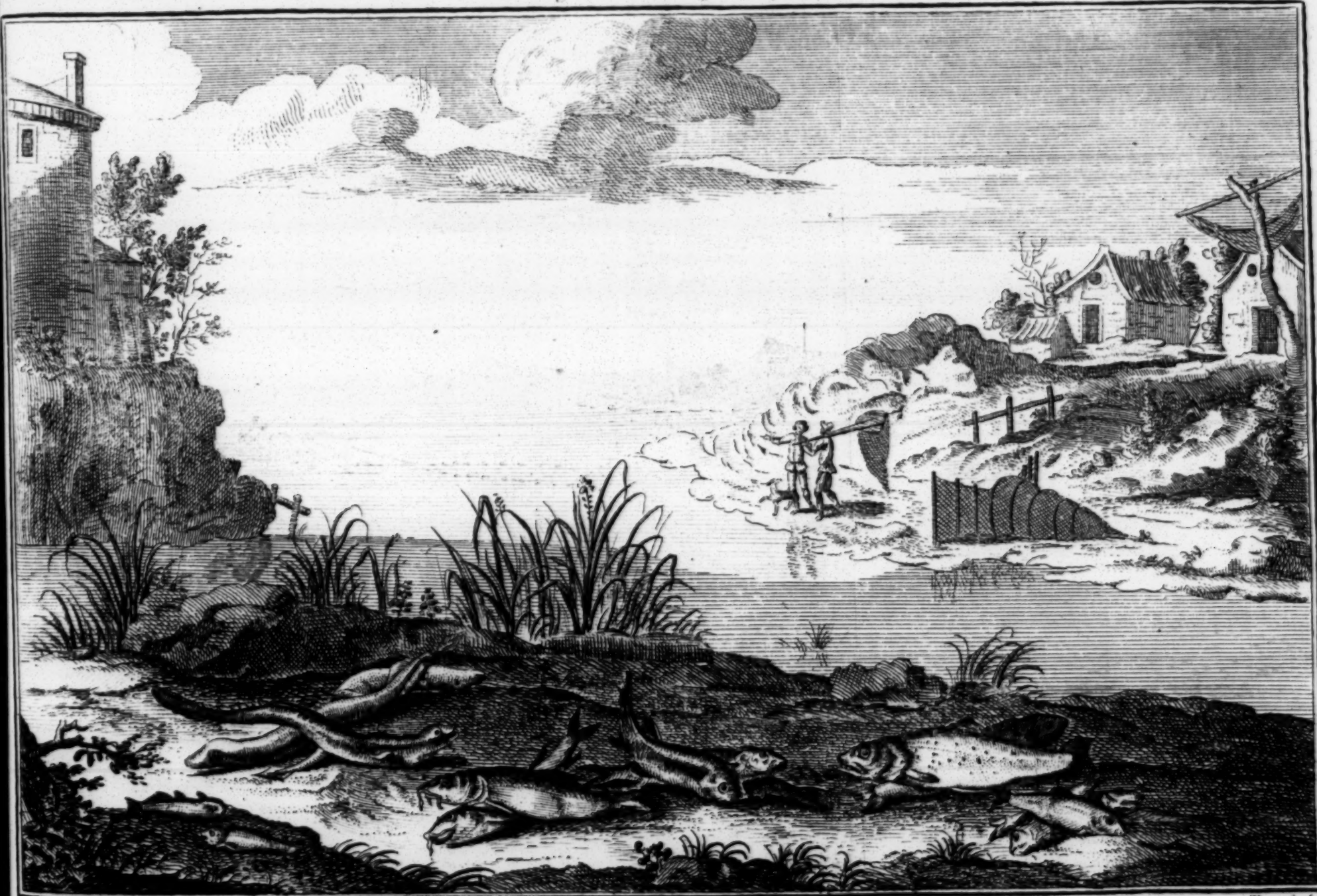
But let us now dive into the Rivers for another sort of Riches which we are more sure to find in them, and may come at more easily ; I mean, the Fish they produce for our Nourishment. The innumerable Productions that the Sea abounds with are very surprizing, but those of the Rivers are still more wonderful ; and yet if the Fishes that are therein had not by natural Instinct been endowed with that Sagacity and Cunning, those many Arts and Shifts for the Preservation of their Species which we see them put in Practice, (and which do not more contribute to their Safety than our Benefit) it would have been impossible for any of them, in so small an Extent of Water, to escape a hundred different sorts of Traps and Engines that are almost every where employed to surprize them.

Chevalier. I believe, Sir, that, in order to give me a fishing Entertainment, you have set all the Inhabitants of the Place to work ; I see so many Boats, Oars, Rods, Nets, and Arms, all in Motion together. The vast Variety quite confounds me ; pray therefore be so kind as to give me a particular Account of what they are all doing.

Prior. With all my Heart, Sir. To begin then with these here : That is the Father of a Family, who with his Sons is casting that great long Net out of the Boat, which

is called a Drag-Net. One End of the
 The Drag-Net, Net they fasten to a Stake on the Shore ;
Sagena. then taking in as great a Compass of the

River as they can with the Boat, casting the Net, which is laid in Folds in the Boat, at the same time, into the Water, they make a Circuit, and come round again to the same Shore : The Top of the Net remains suspended upon the Surface of the Water, by means of Floats of Cork that are fastened to it ; the lower Part of it is sunk to the Bottom, being strung with Plum-bets of Lead from one End to the other, so that it forms as it were, a Wall, or rather an Inclosure bending to a Circle ; by which the Fish are so hemmed in, that they can only make to that Part of the Shore that remains



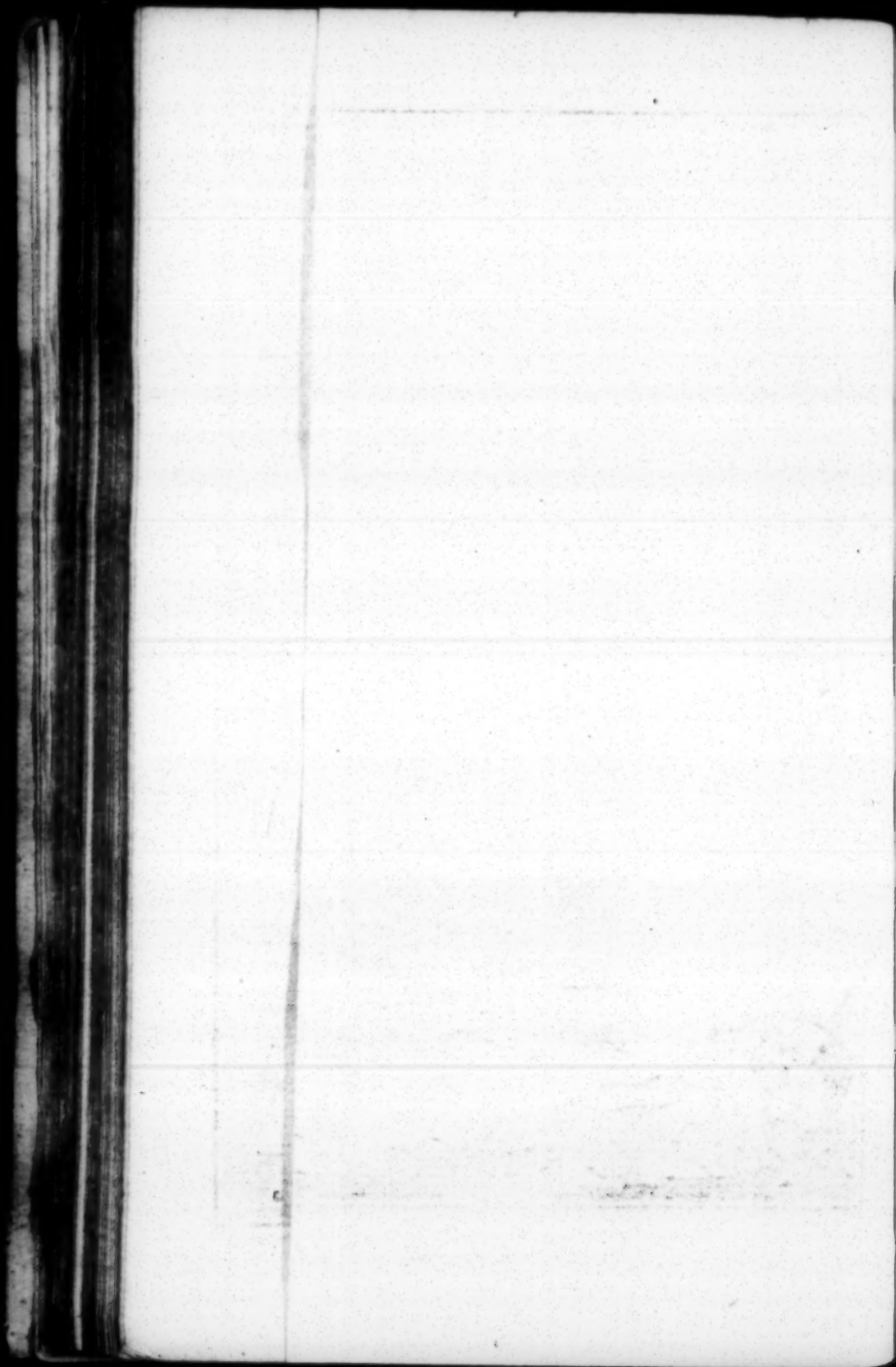
Chubs, Eels & Lampreys, Barbels,

Pollards,

Trouts,

Tench,

Wm. Gelp



to complete the Circle which the Net has not yet described; therefore, to prevent their Escape this way, the Fisherman's Boys disturb the Water on that Side by paddling in it with their Feet, at the same time drawing the End of the Net by degrees to the other that is fixed upon the Shore. The Fish being thus scared, make to the opposite Side, where they are entangled by the Net. The Circumference being thus completed, they take hold of both Ends of the Net together, and draw it to the Shore, thus lessening the Circle by little and little, till the Fish find themselves, as it were, shut up in a Sack, the Bottom of which is closed by the Plumbets of Lead, that drag upon the Ground till they come close together. The Fisherman having thus secured his Booty, casts the little Fry again into the River, that may one Day requite his Kindness by a more profitable Visit; such as are of a proper Size, and fit for his Purpose, he puts into the Well in his Boat.

Chevalier. Pray let us draw near and see what Sort of a Cast they have got.

*Rondellet. L'E-
meri. Willugbbi.
Carp. Cyprinus.*

Prior. You see there are some Carp. This Fish that resembles a Carp, but is flatter and broader, is a Bream; the Scales of it are larger, and the Flesh more flabby. That other whitish Fish that is flatter than the Carp, and with a more picked Snout, is a Dace, and is reckoned very good Meat.

*Bream. Cyprinus
latus.*

Dace. Jaculus.

Those that you see with two Whiskers are Barbels. These others that are shaped like them, but somewhat less, and without Whiskers, are Bull-Heads, or, as some call them, Miller's Thumbs; both these Sorts of Fish are reckoned tolerable Eating, when they are old, and if fed in a running Water.

*Barbel. Barbus.
Bull-Head. Ca-
pito.*

Chevalier. There are some among them I see that I know; those that have the Ridge of Prickles upon their Backs are Perch, those with the gilded Scales are Tench. There are also Gudgeons, Smelts, and

*Perch. Perca.
Tench. Tinca.
Gudgeon. Gobio.*

Loaches,

Loaches, which are all pretty much alike; but the rest I am not acquainted with.

Prior. These Eel-pouts which you see here are very like the Fish called in *Latin*, *Motella*; they have the same Slime all over their Bodies, the same Number of Fins down their Backs and Bellies to the Extremity of their Tails, and have both alike a very large Liver, which has an exquisite Taste; but they differ in this, that the Head and Tail of the *Motella* are somewhat more round, and like a Cylinder; whereas in the Eel-pout they lengthen taper-wise into a Point. The Spawn of these Fish is not good to eat, any more than that of the Pike and Barbel, by reason that it purges violently. The other little Fishes that you see, are nothing but a Heap of Chubs, which have a very large Head, their Bodies lessening towards the Tail; and Minnows, the Flesh of which is reckoned very good (These Fish are distinguishable by the agreeable Variety of their Colours); of Loaches, which make amends for their Smallness by their Sweetness; and of Roaches, which they sling into Ponds to be Food for Pike and other Fishes of Prey: Nay, even the very Bleak is not without its Use; for with the Scales of this Fish they make a Sort of Varnish, which being artificially laid on Beads of Wax or Glass, makes them look exactly like Pearl.

Chevalier. Pray what is that Man about, who looks so intently upon the Water as he stands upon the Shore?

Prior. In his left Hand he holds the Cord, to which is fastened the Apex or Top of his Casting-Net, which is made in the Form of a Cone or Tunnel. The Bottom Part of it consequently is a Circle, about one third of which he bears upon his left Shoulder, another he holds in his right Hand, and the rest he lets hang down before him. He always keeps his Eyes intently fixed upon the Place wherein he has thrown Worms or any other Bait; and when he perceives any Motion in the

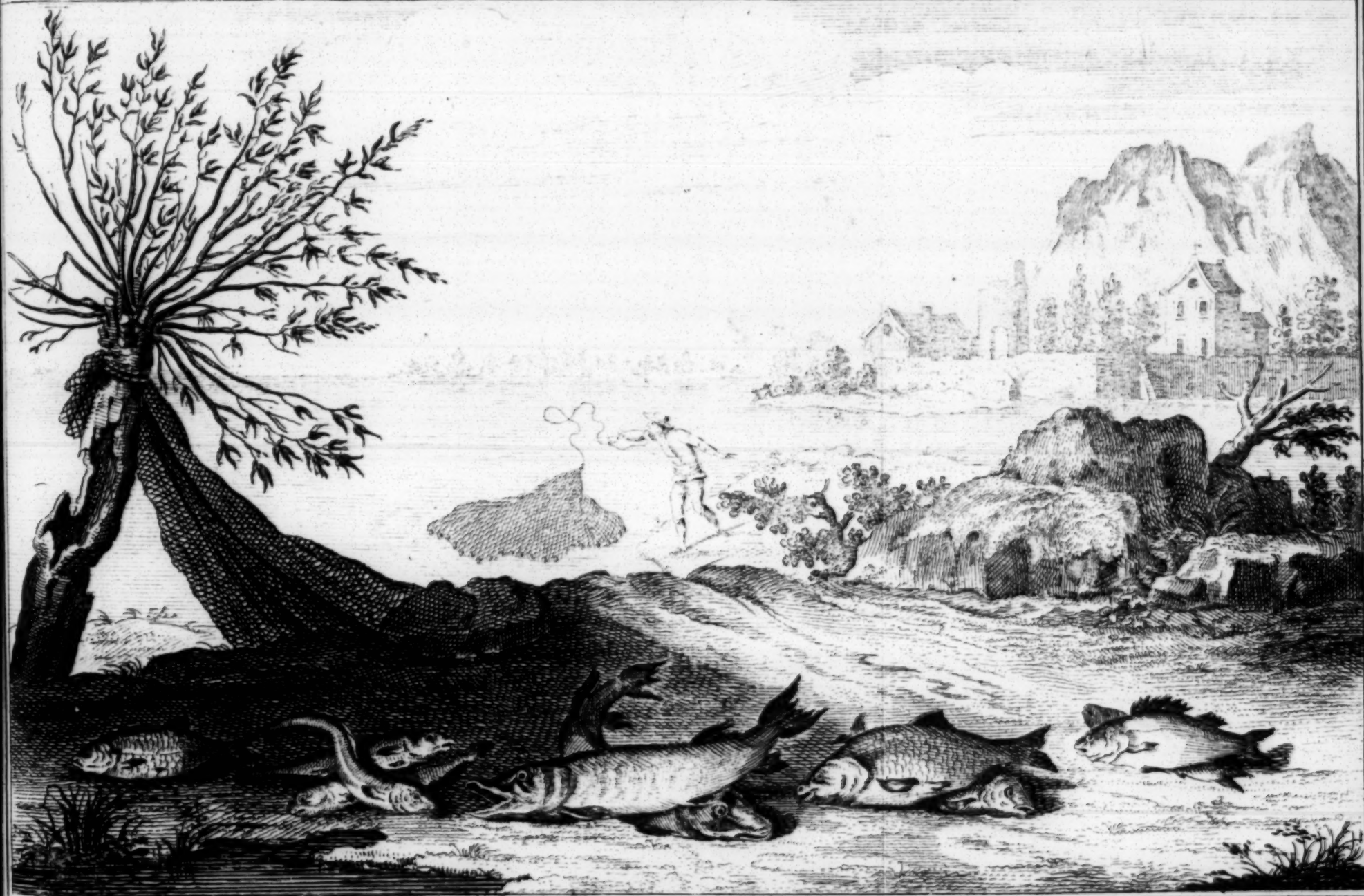
Eel-pout. *Motella.*

Chub. *Cottus.*

Loach. *Apua* or *Cobitis.* Roach. *Flexinus.*

Bleak. *Alburnus.*

The Casting-Net.



Roach—

Eel-Pouts—

Pike—

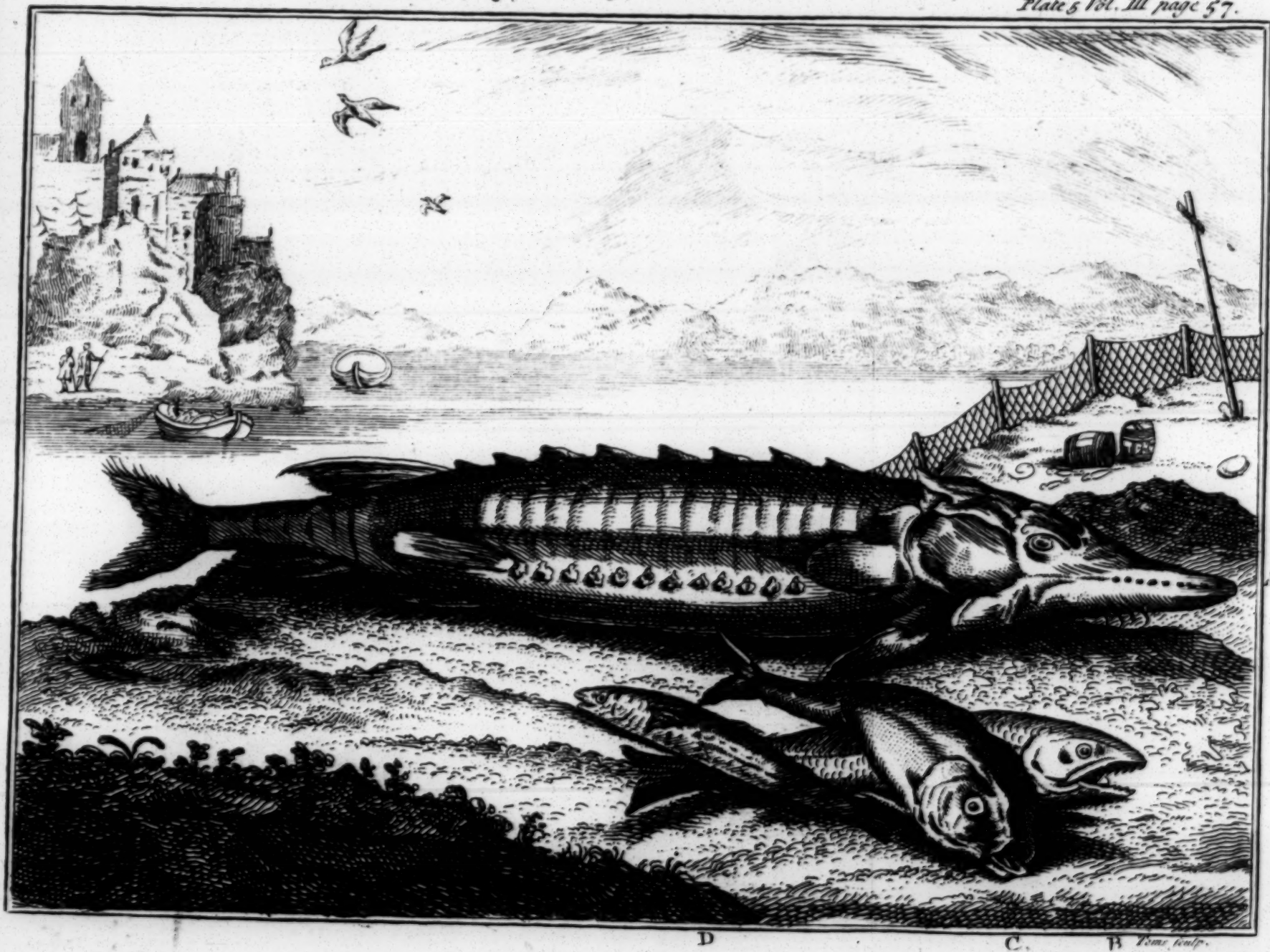
Bream—

Perch—

Toms sculp.

Fish which pass out of the Sea into the Rivers

Plate 5 181. III page 57.



the Water, but especially if he sees a Number of Fishes sporting together, he leans back his Head, and swinging his Arms from left to right, he casts the Net from him, as you behold the very Moment I am speaking to you: The Lead which hangs round the lower Part of the Net sinks it immediately to the Bottom, and the Cord that he holds in his Hand gives him full Command over the Net to draw it back when he pleases; which being of a conic Figure, as he draws it by the Top, it closes at Bottom, by reason of the leaden Plumbets which come together as they are dragged along the Ground. The Net being taken out of the Water, whatever happened to be under it at the Time of its being cast, becomes certain Booty.

Chevalier. Our Fisherman here has not made a random Cast of it; for he has taken a very fine Fish Prisoner.

Prior. It is a Shad-Fish * which he baited for by throwing in a Handful or Shad. *Alofa*, two of Salt in the Place where probably he spied it before.

Chevalier. Pray what is the Use of these Grates which I see placed at the Entrance of these two little Creeks that have a Communication with the River, and why are they made so to meet at their Extremities pointing inward towards the Ditch?

Prior. These two little Grates made of wooden Bars are thus formed in an Angle, that being impelled by any Force in the Line of Di- Salmon-Fishing. rection from the River, they may give way, and open a little at the Point of Contact, and immediately shut again, closing the Angle. Now the Salmon, which, like the Shad-Fish, at certain Seasons of the Year leaves the Sea, and comes up into the Rivers, seeking muddy Waters and By-ways, comes to these little Grills, which open and suffer it to pass through; but shut again, thereby preventing its Return. The Salmon is also caught

* The Shad-Fish called in *French*, *Alofe*, though shaped like the common Sort of Shads with us, yet differs from them both in Size and Goodness, being both larger and better tasted. It is probably a different Sort of the same Species. Our Fishermen sometimes, though seldom, catch this Fish with your common Shads. They call it an *Alofe*.

in Nets, or with the Spear, which is a Sort of Fork that they dart into him when they see him swimming near the Surface of the Water. It is customary likewise to catch Salmon and many other Sorts of Fish with a Candle and Lanthorn, or a Wisp of Straw set on Fire upon the Shore, which the Fish mistaking for the Day-light, make towards it, and are struck with the Spear, or taken in a Net, which they lift up with a sudden Jerk from the Bottom, having placed it the Evening before opposite to where the Fire is kindled.

Chevalier. Pray let us follow those two Boats that are coming out of the great River into the little one; I suppose they are upon some new Scheme of Fishing.

Prior. They are going to take up the Weels which lie about the Mill, or the Trammel-Nets that are placed in the Mouth of the little Rivers. These are a sort of Traps that

lie in Ambush for the Fishes Day and Night, without requiring any Trouble or Attendance of the Fisherman.

The Weels are a sort of long Cages made of Osier Twigs, with a Hole at the Top growing narrower downwards like a Mouse-trap, till the Osier Twigs converge at last almost to a Point; they easily open to let the Fish pass in, but oppose their sharp Points to him when he attempts to return.

Chevalier. See, our Fishermen have found in their Weels one Eel and two Lampreys; I

Eel. know the Eel by the Make of his two Fins, and the Lampreys by the Holes

Lampreys. which are of each Side a little below the Head, and which probably serve

them for Respiration.

Prior. Or perhaps for the Discharge of the Water which enters in with their Nourishment; which Office, as I take it, is performed in other Fish by their Gills.

Chevalier. Pray how is the Trammel-

Trammel-Net. Net made?

Prior. You will see it taken up presently. It is a great Net consisting of two Wings, and several Hoops: The two Wings are supported by several Stakes

Stakes driven into the Bottom of the River, and are extended, if it may be done, to each Side of it, that by thus taking up the whole Breadth it may determine the Motion of all the Fish towards the Hoops where the two Wings meet in an Angle. The Hoops are covered over with Net-Work, and are placed one behind another, decreasing from the first like a Cone from its Base; the Net, which is fastened within the first and largest Hoop, is extended through the rest, growing taper likewise as it lengthens; it is tied also to the Trammel-Net with four Lines, which are so disposed as to give way and widen as the Fish strives to force his Passage inward, but unite when he is got through them, and bar all Hopes of his returning the same way. See what they have found yonder in the Bottom of their Trammel-Net.

Chevalier. They are little Salmon, if I am not mistaken.

Prior. They are Trouts, which, save that their Scales are somewhat smaller, are Trout. *Trutta.* very like Salmon in every respect, if they are not a Species of them.

Chevalier. Pray, when the Fish leave the main River to come up into Ponds, or any little Creek they meet with, what do they get by the Exchange?

Prior. Some of them go in quest of muddy Waters; others to seek for Springs; but what chiefly induces them to leave the Current for Meers and other standing Waters is, that Water-Worms and other aquatick Insects, which make the principal Part of their Food, are found in greater Plenty in your still Waters, and lay their Eggs there in greater abundance, than in the Rivers; and the Reason of their swimming against the Stream is, that they may catch those Insects which are carried down with the Current.

Chevalier. I may judge by what you told me some time ago of the little Worms that are generated from the Gnat, of what great Service Insects are in supplying Fish with Provision. I shall take care for the future how I complain of Insects, after having learned that for my Use they feast the Trout, the Perch, and a hundred other delicate Sorts of Fish. But pray what means that long Cord that they are pulling out of the River?

Prior. This is another Sort of a Trap to catch Fish; they call them Bottom-Lines, and they watch for their Prey in the Night while the Fisherman sleeps. It is a long Cord which reaches the whole Breadth of the River, and is fastened at each End to the Roots of Trees or Stakes upon the Shore. To this Cord are fastened thirty or forty Lines, each having a Hook covered with a Bait; which the hungry Fish no sooner sees but he greedily swallows both together, and so is caught, as was the Fate of those Pikes which you see the Fishermen taking from off their Lines. But none are allowed to practise this secret way of catching Fish, except those that have Shares in Rivers, or such as farm them of the Proprietors. As for Angling, it does so little Harm, that every body is at Liberty to take this Diversion, that has Leisure and Patience enough to follow it.

Chevalier. Sure this River must be well stocked with Fish to employ so many Engines of Destruction; but besides the Bottom-Line, the Weels, and the Trammel or Sweep-Net, methinks I see another Sort of Net which they let down in the Water; pray what is the Name and Use of that?

Prior. It is called a Bag-Net or Pod-Net. The Structure of it is very simple, and the Use of it very diverting. It is made of half a Hoop morticed at both Ends into the Extremities of a Lath or flat Piece of Wood three or four Foot long, and fixed in exact Equilibrium at the End of a long Pole. When you have a Mind to use this Net, the Servant that attends you, or your Friend that shares the Pastime with you, carries with him a long Stick or Pole, with a thick Head of Wood at the End of it, in Form of a Mallet, to trouble the Water. You let down your Bag-Net into some narrow Part of the Channel, the Breadth of which it may take up; if one Net is not sufficient for this Purpose, place two a-breast directly against the Current of the River, that the Water running through may keep the Nets open and extended: He that carries the long Pole to trouble the Water, goes twenty or thirty Paces higher up, where he strikes it against the Bottom, and beats the Rushes and Roots of Trees with it,

it, thereby chasing the Fishes from their lurking Places, which being thus driven from their Shelter, while they think to make their Escape, run into the fatal Bag that intercepts their Flight. The Concussion of the Pole immediately communicates to the Hand of the Fisherman the News of his Prisoner's being taken, who thereupon plucks up the Net, and seizes the Captive: You see how he does it, nothing can be easier, and you yourself might learn in a Minute to catch Fish the same way. Our Fisherman will tell you what Places in the River are best for this Sport, when he comes to them: In the mean Time observe how intent he is on the Pursuit of his Diversion; you do not see him idly rejoicing over his Victory, or measuring the Dimension of the Fishes he has caught; but he puts them strait into his Pannier, and nimbly hastens higher up, though as silently as he can, to put down his Net again in the Place where the Water was first troubled. In the mean time, the Person with the stirring Pole runs before to begin the same Work again: Thus they renew their Sport, shifting their Places at every fresh Trial: They often make frequent Experiments indeed without getting any thing, but one Hit makes amends for several Misses; and a single Pike or Carp of a tolerable Size will compensate for the Fatigue of a whole Day; and though they cannot every Day brag of their Success, yet they seldom return home empty-handed.

Chevalier. Pray what are all those Children doing, that we see so busily employed along the Sides of that Rivulet that crosses the Meadow? Is that another Kind of Fishing?

Prior. There is no Brook nor Stream, how little soever it be, that does not contribute to our Diversion; that which you now see is reckoned excellent for Cray-Fish, the catching of which is Cray-Fish. accounted no mean Sport. The Manner of taking them is thus: They take a Dozen or two of Rods or little Sticks, and split them at the End to put the Bait in; they then stick them in the Mud along the Side of the Rivulet, at about eight or ten Feet Distance from one another. Let it be remarked, by the way, that after Sun-set is the best Time for this Sport, as well because

cause the Cool of the Evening suits best with this Exercise, as because this Sort of Fish feeds best then. But to proceed; every one that follows this Sport provides himself with a little Pannier or Basket made of Rushes, with a long Handle to it; for Cray-Fish are less scared with Green, than any other Colour. If upon taking up the Sticks they perceive any Game cleaving to the Bait, they gently slide the Basket under it, that the Fish, which being lifted up to the Top of the Water always quits its Hold, may fall into it; and thus they will sometimes catch Ten or a Dozen at once. Those that have a mind to be more expeditious in catching these Fish, take a Bundle of Thorns, and lard it well with the Thighs of Frogs, and sling it into the Water; in the Evening the Cray-Fish throng about in Shoals, and so entangle themselves in the Thorns, that by gently pulling up the Cord that is fastened to the Bundle, and slipping a Basket underneath it, you may catch them every one. Afterwards it is very diverting to see the young Fishers laying out their Booty to the best Advantage on the Grass, or to hear them, as they return home, every one boasting of his Success; one triumphs in having caught the greatest Number, another values himself upon having taken the largest, though perhaps the very biggest of them are not to brag of.

Chevalier. I hear the Fisherman bidding his Son to go and cast all the little Carp into the Pond; pray what is the Reason of that Order?

Prior. It is a very good Method; for in one or two Years time all these little Carp will grow to be sizeable Fish, and bring great Profit to the Proprietor.

Chevalier. I suppose they must be at the Pains of feeding them.

Prior. There is no Necessity for that, seeing Nature does sufficiently provide for them: Nevertheless there are certain necessary Methods of Care and Caution to be used with Fish-Ponds; and others, though not so absolutely necessary, yet of great Use to augment the Profit of them. For Ex-

Fish-Ponds. ample, it is proper to have the Pond situated, if possible, at the Foot of a Hill, that the Waters which descend from it may replenish it with Mud, Worms, and other Insects,

sects, that the Fish are wont to feed on: Great Care also must be taken that the Edges of the Pond be raised high with Banks of Earth, that the River, which, by its Communication with it through a close Grate, supplies it with fresh Water and Provision, may not by any Inundation overflow the Banks of the Pond, and at once sweep away the Product of many Years. As for feeding them, it is neither attended with Trouble nor Expence; for the Farmers Children make this Office their Pastime and Diversion, by catching Caterpillars, Butterflies, small Flies, and other Insects, and sling them to the Carp, which are very fond of them.

There are some Days in *May* and *August*, when after a moderate Rain there appears on a sudden, as if dropped from the Clouds, a vast Multitude of little white Butterflies, which are very short-lived, and therefore are called Ephemeran or Day-Flies: They seek the Water, as being the Place where they lay their Eggs, and descend in such Swarms upon the Surface of Ponds and Rivers as almost to cover them. They swim on the Top of the Water by the Motion of their Tails, which keep them up, being plumed with little Feathers in the Shape of Fishes Fins. The Carp, and the other Inhabitants of the Water, immediately make to the Place where this Kind of Manna falls, with which they so feast themselves, that the Fishers tell you, that after the Descent of these Flies the Fish presently grow fat and more quiet, not darting up and down in that restless manner in quest of Food, nor having Occasion for any more Provision for five or six Weeks afterwards. The little Worms that are hatched by the Eggs which precipitate to the Bottom, convert into Nymphs or Crysalis's which serve for the Provision of another Season.

Ephemeran-
Flies.

It is no small Part of Husbandry to save the Crumbs and broken Scraps that are left at Table, to sling to the Carp; nor is it a little diverting to behold them scrambling and striving for little Pieces of Bread; which they are so covetous of, that you will see them of their own accord hastening at the time of Day to the Place where they are wont to be fed, and that, without the Person's shewing himself, at a certain Noise that he makes, at which they

they will all come together as it were at the Signal of a Dinner-Bell.

Chevalier. This is an undeniable Argument that Fishes have Organs of hearing different from their Gills, which were given them for quite another Use ; and I am confirmed in this Opinion, by observing that your Fishers go to work as silent as possible, and love to have every thing still and quiet about them.

Prior. We are come now, Sir, to those Places which afford the greatest Plenty of Fish, where, if you please, you may divert yourself with the Bag-Net.

Chevalier. I took particular Notice of their Manner of fishing with this Net, and don't doubt but I shall catch an elegant Dish for Supper.

Prior. If the Sport prove entertaining to you, though you catch but a Gudgeon, it will please me more than either Trout or Shad.

FOUNTAINS.

DIALOGUE XX.

The PRIOR and CHEVALIER.

Chevalier. **I** Perceive, Sir, it was not without Design that you have conducted me to the Borders of this Fountain ; you had a Mind to make me acquainted with one of the most delightful Places hereabouts.

Prior. The Design I had formed to entertain you with a Discourse on Fountains, almost insensibly led me hither. Pray, what, in your Opinion, can be the Cause of this perpetual Motion of Water, which though serene, uniform, and almost always the same, yet attracts our Eyes
by

by a secret Sort of Charm, that makes them never tired with gazing on it? If we reflect, on one hand, there is no Effect in Nature either more visible or ornamental than this inexhaustible Flux of Fountains, and the Course of Rivers, which continue for whole Ages to roll along in a floating State, and to fill their spacious Beds with never-failing Plenty. On the other hand, there is no Effect whose Cause Nature seems more industriously to have kept concealed from us. What Source is sufficient to feed such a River as the *Rhone*? What Store-Houses large enough to supply the mighty Cisterns of the *Danube*, the *Ganges*, or the River of the *Amazons*? Where are those eternal, (if I may be allowed the Word) immense, invisible Reservoirs, which through so many hidden Channels pour forth such inexhaustible Treasures of Water, filling the vast Bosoms of the Rivers with a Profusion abundantly sufficient for all our Wants, and yet restrained within such proper Bounds as not to overflow, instead of enriching the Countries they pass through?

The Supreme Being in thus discovering to us the Course, and concealing from us the Source of Rivers, seems to have been pleased to make them an Emblem of his own Nature, which in like manner is always fruitful and beneficent, though at the same time invisible to us. The Liberality of our great Creator, like them, is perpetual, magnificent, inexhaustible, without Ostentation, and without Reserve; it showers down Blessings upon the most Undeserving; and as it is never weary with giving, so neither does it upbraid us with its Gifts; its Benefits are universal, and conspicuous to all, whilst the Hand that distributes them is hidden from our Eyes.

Chevalier. Does not God seem to have forbid all Inquiry into the Origin of Fountains by having thus concealed it from us?

Prior. We are not to suppose that God does prohibit our Inspection into every thing that he has cast a Veil over, nor are all his Ways unsearchable because not obvious; nay, he has implanted in us a natural Desire of attaining to a more complete Knowledge of those Things which we have at first but a very imperfect Acquaintance with; and as we are apt to wonder at those Works of God, whose Causes and first Principles we are ignorant of,

so do we find another kind of Admiration raised in our Minds, in Proportion as we grow acquainted with the Formation, Workmanship, and Beauty of them ; let us then endeavour to penetrate into the hidden Cause of Rivers ; for I am persuaded that whatever new Discoveries we are able to make in a Phænomenon we are so conversant with, and in which we daily discern the Footsteps of our Creator's most amazing Liberality, cannot fail to heighten our grateful Adoration of him.

When I look for the Origin of the *Seine*, the *Garonne*, or the *Rhine*, or when I would trace the smallest as well as the largest Rivers to their Sources, I never find them rising in the middle of Plains, but all, at least as many as I am acquainted with, issuing out from the bottom or middle of Mountains ; now what particular Privilege or Property belongs to them, that they should thus be made the only Magazines of such vast Collections of Water ? The Mountains, it is true, by their Elevation above the Plains, are advantageously situated for the supplying Rivers with their proper Contingents of Water ; but how come the Mountains by their Stores ? For we see no Reservoirs on the Tops of them, sufficient to support such a perpetual Consumption.

Chevalier. We are not, as I take it, Sir, to look upon the Tops of Mountains for those Reservoirs that feed the Springs, but into the Bowels of the Earth ; we must descend to the Sea, which is the great Source of this Circulation of Waters ; the Fountains supply the Rivers, the Rivers discharge themselves into the Sea, and the Sea, which would otherwise be over-charged, again restores to the Mountains the Tribute it receives from the Rivers, in order to feed the Springs.

Prior. This will admit of no Doubt ; but consider, there is a vast Distance betwixt the Sea and some Mountains ; how then will you account for the Conveyance of the Water so long a Journey ?

Chevalier. Here indeed lies the Difficulty.

Prior. There are but three Hypotheses of any tolerable Repute relating to this Question, whereof to chuse : all others, it is allowed by every body, are not worth mentioning, much less the Trouble of confuting.

The first Hypothesis is that of Mr. *Des Cartes*, who was of Opinion that the Water of the Sea diffused itself in all Directions under Ground, and that coming to the Bottoms of Mountains, it there met with large Caverns, into which being rarefied by the central Heat beneath, it ascended in Vapours, leaving its Salts behind, as being specifically heavier; that these Vapours being impeded in their Ascent by the Tops of the Caverns, there condensed, forming little Streams or Currents of Water, like the Steam in the Head of an Alembick.

The second Hypothesis lays down, that the Sea-Water percolates through the Pores of the Earth, which, though large enough for the finer Parts of the Fluid to permeate, yet are so small as to deny Admittance to the saline Particles that are commixed with them; which the Water in the Course of its Filtration leaves behind, thus refining and purifying itself, till it becomes fresh and potable, before it mixes with the Fountains and Rivers.

Those that are Advocates for the third Hypothesis maintain, that the Sea has no Communication with the Mountains by any subterraneous Channels, but only above the Earth; that there perpetually arises a Vapour from the Surface of Rivers, Lakes, and the Sea, that is carried through the Atmosphere, in the form of a Cloud or a Mist, by the Impulse of Winds; and that, according as it meets with a colder Air, or is stopt in its Progress by Mountains, it condenses and falls down in Dew, Snow, or Rain; that the Water, in which soever of these Shapes it descends, does afterwards find several Chinks and Crannies, through which it insinuates itself into the main Body of the Hills or Mountains, where it is lodged in Beds of Stone or Clay, according to the Nature of the Soil; where by Degrees increasing its Store and Strength, it forces its Way through the first Outlet it meets with, and takes the Name of a temporary or perennial Fountain, according to the Capacity of the Basen within that supplies its Current.

Chevalier. Father *Rapin* discoursing on the Origin of Fountains seems to set light by the Opinion of those who would endeavour to solve this Phænomenon from the Condensation of rarefied Vapours in the vaulted Caverns of Hills; nor does he make any greater Account of that
other

other Hypothesis which ascribes it to Rain ; but favours the Philosophy of those who attribute the Rise of Springs, to the Sea-Water filtrated through the Pores of the Earth. He has given us these different Opinions, especially the last, in very exalted Strains of Poetry ; the Verses pleased me so much, that I took the Pains to get them by Heart.

Prior. We should be glad to hear them, if you please ; here are no Ladies to take Offence at your *Latin*.

Chevalier. They are as follows :

*Nonne vides rapidum Ligerim, ingentemque Garumnam,
Quique Parisiacos fœcundat Sequana Campos,
Et Rhenum, & Scaldim, & Rhodanum, magnumque flu-*
entem

*Danubium, atque alios descendere Montibus Amnes ?
Sive carvis subter Spatium sit inane Cavernis,
Hospitium Undarum ; seu quod spirabilis Aër
Paulatim in tenues longo fuit Agmine Guttas,
Unde ipso tepidæ sudant Humore Cavernæ,
Quales marmoreis Guttas stillare Columnis
Humentis Cælo, & Brumâ nigrante, videmus ;
Rupibus idcirco ex altis permanat Aquarum
Roscidus Humor, & uberibus flent omnia Guttis.
Seu quod per Montis altos Tellure sub ipsâ
Imbribus è Cælo ruptis, Nivibusque solutis,
Multarum sese Vis plurima cogit Aquarum,
Ima petens, donec jam Copia, viribus auctis,
Tum demum erumpat, Campoque insultet aperto.
Nec desunt quorum melior Sententia Menti,
Qui perhibent Fontes Genus altum accersere ab ipso
Oceano. Nam totum Orbem circumfluit ingens
Oceanus, magnæ subter Spiracula Terræ
Qui subit, in tenues fusus ceu Corpore Venas
It Sanguis, totique facit Commercia Moli :
Quo sit uti nusquam crescat Ripisque redundet
Pontus, ubi vasti de Partibus omnibus Orbis
Undique tot tantis concurrunt Fluctibus Amnes.
Interior nam cum raro sit Corpore Tellus,
Inque Specus altos, imperfossosque Meatus
Interdum descendat, & in Loca concava fidat*

*Unda Maris, raræ per curva Foramina Terræ,
 Perque Sinus ipsos furtivo lubrica Lapsu
 Paulatim insinuat sese, cæcumque per imos
 Aut quærit Galles Iter, aut molitur eundo.
 Aut ubicumque magis ruptæ se Viscera Terræ
 Diducunt, crebroque patent ad aperta Meatu,
 Tum largus magis atque magis se fundit Aquæ Fons.
 Idcirco Latices manant ex Æquore salso
 Non falsi; nam cum multum Tellure sub imâ
 Multiplices se per Salebras & acerba Locorum,
 Perque cavos Flexus & inæquales per Arenas
 Torisit agens Maris unda, Salis quæ crassa marini
 Materies hærebat Aquæ purgatur, & omne,
 Ceu per Cola means, Vitium detergitur Undæ.*

Prior. These Verses have indeed all the Softness and smooth flowing Numbers of *Lucretius*, joined to the Spirit and Energy of *Virgil*; but let us see if the Philosophy of them will stand the Test as well as the Poetry.

The first Opinion that Father *Rapin* undertakes to confute, may be defended two Ways; first, by laying down, that the external Air being replete with Vapours, does, upon their Condensation, discharge them into the Reservoirs of the Mountains, which exactly tallies with the Philosophy of those who ascribe the Origin of Fountains to Rain and Vapours, which we will take under Examination in its proper Place; or, secondly, it may fall in with the Opinion of Mr. *Des Cartes*, and suppose that the Water of the Sea finds a free Passage under the Earth to the Bottoms of Mountains, into which it ascends in Mists, where it is condensed into large Drops by the Sides of the Rocks; but this is not strictly agreeable to Truth: for in the first Place, it is begging the Question to suppose any such free Passages of Communication betwixt the Sea and the Feet of Mountains; nor can any Experiment be produced to warrant the Supposition of these subterraneous Channels; on the contrary, where-ever running Waters have been discovered under Ground, it has been observed that they run from the Mountains * to the Sea, and not contrariwise.

* *Valisneri Annotazioni intorno all' Origine delle Fontane, 1714.*

But

But granting that the Waters have as free a Passage as they can desire, and steer their Course without any Interruption to the Place of Rendezvous, what will follow? Why then it is pretended, that they, meeting there with a sufficient Degree of Heat to rarefy them, ascend in Vapours into the vaulted Caverns of the Rocks, where they are condensed by the Cold, and trickle down the Sides in great Drops, as in the Head of a Still; that then finding a Passage through the Sides of the Hills, they issue forth into the open Air under the Name of Springs, and descend upon the Plains; but this is to order Things just as they would have them, and not as they really are in themselves; for allowing, as we said before, the Waters a free Passage from the Sea two or three hundred Leagues in Length under the Ground, to the Roots of high Mountains; pray, where are the Furnaces which remain in such a constant State of Readiness and Heat, to rarefy these Waters, and make them evaporate in Clouds? Allowing still farther, that there is a sufficient Degree of Heat for this Purpose, yet where are those Caverns six or seven hundred Paces high, whose cool Vaults are to condense these exhaled Vapours? It is certain that People have digged and penetrated far enough into the Bowels of the Earth and Mountains to make the Discovery, though without having ever found Caverns big enough to allow the Vapours a free Ascent to the Height of the Fountains from which the Rivers take their Source; so that these marvellous Alembicks are nothing more than mere Fancies.

Chevalier. There occurs to me another Reason for rejecting this Hypothesis, which is this; that though we should allow such an Assemblage of Waters under the Mountains a sufficient Heat to rarefy them into Vapours, and Caverns high enough for them to ascend up to the middle of the highest Mountains, yet all these Concessions would avail nothing, nor the Concurrence of all these Causes produce the least Stream of fresh Water; for the Vapours adhering to the Sides of the Caverns, and there condensing, not finding any Receptacle to lodge in, whence they might issue out through the Sides in Springs, must necessarily fall down again into the Bason, from which they arose.

Prior.

Prior. Your Remark is very just ; to which I will add two other Proofs, which are Matters of Fact, that will thoroughly convince you of the Absurdity of supposing those Alembicks with which Mr. *Des Cartes* seems so highly delighted ; the one I shall take from what passes on the Outside of the Earth, the other from what is observed within it.

After a long Cessation of Rain, whether in Summer or in Winter, it is found by Experience that the greatest Part of Springs fail, several Rivers are drained almost quite dry, and the largest of them have scarce Water enough to cover the Bottoms of their Channels. Now what have the Vapours which ascend from the subterraneous Waters to do with its raining or not raining, seeing they must operate independently of any such Cause ? The Water is in the Alembick, the Cover upon it, and the Furnace always burning ; why then does not the Business of distilling go on ? For if this be the Cause of Fountains, as the Cause always remains the same, the same Effect must always continue to be produced ; nor would any external Drought any ways effect it, which is quite contrary to Experience. Let us, in the next Place, proceed to consider what passes within the Earth ; and here neither do we find any thing that gives the least Colour of Probability to such pretended Evaporations exhaling from the Bottoms of Mountains, to the Tops of them, and there forming great Reservoirs of Water to feed the Springs that issue through their Sides. We hear of People that have visited vast Numbers of Grotto's and Caves of all Dimensions, some of which were perfectly dry, and consequently without having Communication with the Waters that come from the Sea ; others have been found all crusted over by Time, with a congealed, crystalized Fluid ; some having little Currents of Water passing through them ; and others distilling from their vaulted Roofs Drops of Water, which settle at the Bottom. Now it is agreed by the best Judges, that those fluid Globules that sweat through the Pores of the Caves, and there petrify or crystalize, proceed solely from the Rain-Water, which soaking through the Crannies of the Earth and Caves, associate with saline or sandy Particles, and so form themselves into spiral or conick Figures ; in which Metamorphosis the
Sea

Sea visibly has no manner of Share. As for those little Streams of Water that run through some Caves, they are most certainly produced by the Rains which penetrate through the Earth, seeing they are observed to diminish or dry up in Proportion to the Severity or Continuance of the Droughts. And, lastly, it is plain, that that Humidity which distils through the Sides of certain Grotto's can in no wise be ascribed to the Sea-Water, forasmuch as there is none of it found in the Bottom of those Grotto's; and because it is observed, that their Dampness increases in Proportion to the Quantity of Rain that descends into them; whereas by a long Discontinuance of wet Weather, they become entirely dry. We need no other Proof of the Truth of this, than what we see in the Caves of the Royal Observatory at *Paris*, where, in very dry Years, the Water ceases dropping.

Chevalier. The Water of the Fountain we sit by, does not indeed seem to me to have passed through any Alembick; but perhaps it may be conveyed hither directly from the Sea, having left its Salts on the Sides of those subterraneous Channels it has passed through, purging and clearing itself of all heterogeneous Mixtures, by draining through the Rocks and Sands which it visits in its Passage, like Water in a sandy Cistern. This Opinion, which Father *Rapin* has so happily expressed, and which seems to be his favourite one, has very much the Air of Probability on its Side.

Prior. I cannot deny but it is specious and plausible enough; but let us try if upon Examination it will prove satisfactory. In the first Place I cannot conceive what

A Confutation of the Opinion that the Waters of the Sea are filtrated through the Earth.

can become of the Salt, which so many Rivers must have deposited under Ground. It is now about six thousand Years that the Sea, according to this Hypothesis, has been distributing out its Waters and Salts to the Sources of Rivers, without having received in Return from them any other than fresh Water; and consequently it would have happened, by Degrees, either that the Sea must have emptied itself of all its Salts, or the Earth have been so overcharged with them, as that these Salts would have blocked up those subterraneous Channels the Water should pass through

through, in order to supply the Fountains, just as we see the Waters of *Rongis* and *Arcueil*, in less than fifty Years, stop up their own Passage by incrustating the Insides of the Pipes they pass through, with the Sand and Salt that is intermixed with them. But we will endeavour to set this Argument in a clear Light.

The Water of the Rivers, according to the Hypothesis I am now confuting, comes directly to the Fountains from the Sea, through the Pores of the Earth, after having first, by Filtration, deposited all, or nearly all, the Salts which it before contained. Let us compute now what Quantity of Salt the Water of one of our Rivers in *France* may leave under the Earth in a certain determinate Time; and we shall find that the Water of the River *Seine* alone, in one Day's Time, does leave behind it, under Ground, more Salt than is made in our Salt-Pits for the Provision of the Kingdom of *France* for a whole Year. At *Bourgneuf*, *Croisil*, and *Guerande*, on the Coasts of *Bretagne*, and in some other Places on the Coasts of *Aunis* and *Brouage*, we find a great Number of Salt-Pits, or large square Plots of inclosed Ground, well covered with Clay, and hard rammed down, on which they let

in, through a Flood-Gate, a certain Quantity of Sea-Water: In some Places they float their Pits an Inch and a half deep, in others they lay them under Water five or six Inches deep. They chuse for their Salt-works the Summer-Season, when the Weather is driest, and seems settled fair; for Rain of any long Continuance spoils the whole Work, and obliges them to drain off the Sea-Water, which they first let in upon their Pits, and to replenish them with a new Stock. In two or three Days Time, the Sun exhales almost all the Water in the Pit, leaving the Salts behind, which, settling by Degrees, unite and harden into one continued thin Crust or crystal Surface: This they break with long Poles, or a sort of Rakes, upon which the large Flakes of Salt fall into the Water that remains underneath, which is found to be exceeding hot. They then rake together these Flakes of Salt, and after that, drain them from the Wet, and dry them, in order to be pulverized. The Salt being thus made, they are in the first Place obliged to deliver in

The Way of making common Salt.

The Ordinance of
the Gabel.

to the Officer of the King's Duties fifteen thousand Muids * of Salt ; the remaining Quantity, which is much more considerable, is sold by the Proprietors to the People of the Northern Countries, who supply themselves with this Commodity from *France*, as being excellent in its Kind. A Fortnight of settled fair Weather is reckoned sufficient Time for making one Year's Provision of Salt. We will ground our Calculation but on the fifteen thousand Muids which are yearly consumed in *France*, without taking into the Account what is sold to Foreigners.

It has been found by repeated Experiments †, that two Pounds of Sea-Water will yield eight Drams, and ten Grains of Salt ; we will say only eight Drams, that our Calculation may be allowed moderate and unexceptionable. An Ounce, or eight Drams, is the sixteenth Part of a Pound, or the two and thirtieth of two Pounds ; therefore thirty-two Ounces or two Pounds of Sea-Water are sufficient to produce one Ounce of Salt in the Pit ; to produce a Pound of Salt thirty-two Pounds of Water are required ; to produce two Pounds of Salt, sixty-four of Water, and so on in Proportion : But granting still further, that a cubick Foot of Water, which weighs seventy Pounds, will produce only two Pounds of Salt, it will then follow, that a cubick Foot of Sea-Water must deposit under Ground, at least, two Pounds of Salt, before it arrives at the Source of a River, where it becomes perfectly fresh.

The celebrated Mr. *Mariotte* has calculated, with all imaginable Exactness, the Quantity of Water that runs through the *Pont-Royal* in the Space of twenty-four Hours, and has found the Sum total to amount to two hundred and eighty-eight Millions of cubick Feet. But as those who maintain that Rivers do derive their principal Stores from the Sea, do not deny but that they are increased by the Rains ; we will therefore content ourselves with supposing that every cubick Foot of fresh Water has only

* A Muid contains twelve Sacks, every Sack four Minots, and each Minot weighs a hundred Pounds.

† History of the Sea by Mr. *Le Comte de Marfilly*, Part 2. Page 27.

left behind it one Pound of Salt instead of two; according to which moderate Computation, the Water of the River *Seine* must deposit under Ground in one Day two hundred and eighty-eight Million of Pounds of Salt, which is treble the Quantity of what our Salt-Pits bring yearly into the Gabels of *France*; seeing the annual Provision which arises from them amounts but to fifteen thousand Muids. Every Muid weighs four thousand eight hundred Pounds, and consequently fifteen thousand Muids multiplied by four thousand eight hundred give no more than seventy-two Millions of Pounds. If we multiply the two hundred eighty-eight Millions of Pounds of Salt, deposited by the River *Seine* in one Day, by three hundred and sixty-five, the Number of Days in the Year, the Quantity of Salt which the River *Seine* will have deposited under Ground in one Year's time, will amount to above a hundred thousand Millions of Pounds. We have hitherto taken but one River into our Account; what prodigious Quantities of Salt then must be amassed in the Bowels of the Earth from the Sediments of all our Rivers, both small and great, taken together!

Chevalier. But if to the Rivers of *France* we add those of the whole Earth, these Masses of Salt will in time become bigger than the Mountains, and the Earth must every Year increase and swell with these additional Supplies of Matter.

Prior. It is now five or six thousand Years that these Rivers have been running, and continually depositing two Pounds of Salt for every cubick Foot of Water.

Chevalier. I am now convinced that this Notion of Filtration is absurd; and it appears very plain, that if the Sea-Water did thus continually discharge its Salts into the Bowels of the Earth, the Ocean would long since, by thus passing to and fro through the subterraneous Channels, have lost all its brackish and saline Quality; and that moreover the Salts would have so blocked up the Pores of the Earth as to prevent the Waters passing through them.

Prior. But let us try if we cannot make this Opinion carry some Air of Probability, by supposing that this Secretion of the Salt from the Water is not performed within the Earth, but by the Sands at the Bottom of the

Sea ; and this Conjecture is strengthened by several Fountains of fresh Water that we often observe to spring out at very small Distances from the Sea ; which seems to me to prove that the Work of Filtration is performed immediately before the Water enters into the Earth, and that the Salts remain still at the Bottom of the Sea.

Chevalier. Pray, Sir, be pleased to tell me if these Springs never dry up.

Prior. Yes, most of them do in times of great Scarcity of Rain.

Chevalier. This seems to me an Argument that they take their Rise from an Assemblage of Rain-Water within the Earth, and not from the Sea, which, notwithstanding any Drought, is always equally in a Condition to feed them.

Prior. Your Observation may be seconded by another : If the fresh Waters that are often found in the smallest Islands, and even bordering upon the Sea, proceeded from it by Filtration, it would be a very easy Matter to secrete the Salt from the Sea-Water, and to cure it of its Brackishness, which would prove of infinite Service in Navigation ; whereas we are convinced, by an almost infinite Number of Experiments, of the little Success we are to expect from any Attempts of this Kind, even after straining and filtrating it through a hundred different Sorts of Sand and Vessels. All the Art that we can use with it will only serve to qualify the Degree of its Saltiness, not to take it away ; for in spite of the most skilful and accurate Preparations it still will retain a brackish and bituminous Taste, that renders not only it, but also every thing that is dressed in it intolerably nauseous. It lacerates the Intestines of those that use it, and discolours their Urine with the Blood of those little Vessels which were scratched and torn with the sharp-pointed Salts that are in it.

Chevalier. All the Misfortune perhaps lies in our being ignorant how to filtrate it as it should be, which is no Argument against the Superiority of the Knowledge and Power of God : For my own Part, I cannot help thinking that the Sea-Water leaves its Salts on the Sands beneath, by draining through them ; and then percolating through the Pores of the Earth, is raised by Degrees to
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the Top of it by some certain Power of Attraction ; and that both Sand and other terrestrial Matter has a Power of attracting Water, appears to me very certain, from an Experiment that I made To-day, by putting a Lump of Sugar into a little Coffee, upon which I observed that the Water presently ascended through the Pores of the Sugar up to the Top of it. Yesterday I likewise observed, that some Water, which had been poured upon the Ground at the Bottom of a Heap of Sand, did ascend half Way up the Heap. This seems a just Representation of what the Sea and the Mountains are with regard to each other.

Prior. This is indeed the most plausible Objection that can be started: But to this I answer, that, in the first Place, neither the Sands nor the Earth have that attractive Quality which you seem to think they have; for the Cause of Water's rising in them is owing to the external Pressure of the Air, which forces it up into porous Bodies, in which the grosser Parts of the Air cannot act with free Power. But this Elevation of Water is only to a certain Height; for it has been found by frequent Experiments * made by immersing the End of a Tube, filled with Sand or Earth well dried, in Water, that the Water rises in some Sands to the Height of eighteen, in others to the Height of thirty-two Feet, though it generally falls short of this; and I do not know any one that ever saw it rise higher. Now what Proportion is there, I pray you, betwixt the Ascent of Water, occasioned by the Weight of the Air, to the Height of thirty-two Feet, and its ascending half way up a Mountain a thousand Fathoms high above the Plain? Besides, the Water of the Sea blocks up its own Passage through the Sand and the Earth, by a sort of glutinous Substance, that covers the Bottom of it; and by a vast Quantity of precipitated Salts, that shut up the Interstices of the Sands instead of keeping them open: And to be convinced of the Truth of this, you need only cast a Piece of Wood, a Cord, a Pot-herd, or any thing else, into the Sea; and upon taking it out a few Months after, you will find it covered over with a slimy or viscous sort

* Vegetable Staticks by Stephen Hales, F. R. S.

of a Skin; and this glutinous Matter thickens by Degrees, as if on Purpose designed to hinder the Water from penetrating into the Earth; nay, we even see the very Fishes covered over with it, to prevent the Water from entering in through the Pores of their Bodies, and to preserve them from Putrefaction.

The Wine in a Cask, instead of opening the Pores of the Wood, closes them up by lodging in them a kind of tartareous Salt or Dregs, which keeps the Liquor in, and hinders it from filtrating through the Vessel. So likewise in the Sea there is a sort of Tartar and Glue that settles to the Bottom of it, which serves for the same Purpose.

But allowing that the Water, passing through the Sands, does afterwards insinuate itself into the Pores of the Earth, yet it would be impossible for it to make any considerable Progress; for immediately after Filtration we should see it springing up in the Plains, especially those that are adjacent to the Sea, before it could reach the Mountains, which is contrary to matter of Fact. How comes the Water to seem so averse to the Plains, and so fond of the Mountains? Or if it delights to take a Journey of two or three hundred Leagues to make them a Visit, how will it be able to ascend five or six hundred Fathoms into the Mountains, when it could not rise before to a very inconsiderable Height above its Level to water the Plains? But granting that a very high Tide is able to make the Water ascend into the Bosoms of very high Mountains, what Force, shall we say, hinders it from rising more than half way up, what Power keeps it from ascending still higher, and gaining the Summit? For this it was never known to do. Besides, if the Water, whether by the Pressure of the Air, or the Attraction of the Earth, could thus every where insinuate itself through the subterraneous Veins and Channels of it, the Earth would soon be soaked through, the Sea would forsake its Bed, and mix with the Plains and the Mountains; and, in short, the whole Globe would, in a little time, become like a Sponge.

Chevalier. I must indeed confess, that I cannot conceive what should be the Cause of the Water's passing so regularly through the Pores of the Earth, without spring-
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ing up at the same time in the Plains, or ascending to the Tops of the Mountains: But however difficult this may be to account for, yet it is nothing less than Matter of Fact, that Sea-Water is found in some Places above a hundred Leagues distant from the Sea.

Prior. If you will be so kind, Sir, as to make good your Assertion, I shall think myself obliged to you; for if this be Matter of Fact, it is what I never knew before.

Chevalier. Why, are there not inexhaustible Wells of Salt-Water at *Salins* in *Franche Comté*? And whence can that come but from the Sea? A few Months ago I happened to be at a certain Place, whither a very expert Mathematician * was sent by the King's Orders to take some geographical Lines relating to the Map of *France*, who gave us a very entertaining Account of the Curiosities he had seen in the Mines of *Willisca* in *Poland*, out of which, according to him, they have been digging Salt above four hundred Years; now what but the Sea can supply these Mines with fresh Recruits of Salt, and repair such a vast Consumption of it? Consequently the Water of the Sea does actually penetrate a great way into the Earth.

Prior. Dear Chevalier, I hope I shall be able to demonstrate to you that the Sea has no manner of Communication, either with Salt-Wells or Salt-Mines. But first of all, do me the Favour to inform me of what you heard said of the Mines in *Poland*. I always allow great Weight to the Report of an Eye-Witness, and besides, probably it may serve to confirm the Truth of what I am now maintaining.

Chevalier. The famous Geographer I mentioned to you, told us, † That in 1252 (for I took down the Date in my Pocket-Book) they discovered some Salt-Mines near *Cracow*, and which now make one of the most considerable Branches of the King of *Poland's* Revenues. They are situated under the little Town of *Willisca*, which, except the Church, consists entirely of Houses, or rather Caves dug under Ground. There are four Mouths or

* M. P. Abbé de la Grive.

† *Philosophical Transactions* abridged by J. Lowthorp, T. 2. P. 514.

Openings, through which they go down into the Mines, of which the two principal ones are in the Town; and up through these they draw out the great Flakes of Salt, which they lay before their Doors for Men and Horses to trample upon, and break with their Feet, before they grind them smaller in the Mills. The two other Descents serve chiefly for the letting down through them the Wood and other Necessaries for the Labourers. The Holes are about four or five Foot square, and lined to the very Bottom with strong Planks. Over the Mouth of the Pit is a large Wheel that is turned by a Horse, to which is fastened a great Cable as thick as a Man's Arm, which lets down or draws up what they have Occasion for. Their Manner of going down, which they may do thirty or forty together, is thus: He that is to go first, ties a strong Cord about him fast to the Cable; upon which seating himself, he takes another Labourer upon his Lap; these are let down both together about three or four Foot to make room for another, who in like manner fastens himself with a Cord to the Cable, takes his Companion upon his Knees, and is let down to about the same Depth, that two others may succeed in their Turn: When all those that are to go down have thus taken their Places, the Horse goes round, and unwinds the Cable, till they are all let down, one after another, upon the first Bottom, which is a hundred Fathoms below the Mouth of the Pit. They then quit their Cords, and by the Light of a Lamp advance Sideways through Turnings and Windings, that go sloping all the way down, till they come to the Mouth of a second Pit, that is another hundred Fathoms deep, to the Bottom of which they descend by Ladders disposed in order one above another all the way: So that they are obliged to go above two hundred Fathom deep under the Town before they can come at the Salt-Mines. The Miners there dig indifferently on all Sides, always taking care to support the Top of the Cavity they make with strong Props, and large Pieces of Timber. What is very remarkable in these Places is, that there runs across the Mines a Rivulet of fresh Water, that never dries up but in very severe Droughts, and this serves for Drink and Refreshment to the Labourers, who are above a thousand in

Number

Number besides some Horses, which they use in carrying the Salt to the Bottom of the Pits; as for these poor Creatures, they are condemned to eternal Night, by reason of the Sharpness of the Air, which makes them go blind in a little Time. The Miners every now-and-then ascend up to the Regions of Light, as well for the Benefit of the purer Air, as for the Performance of their religious Duties.

Prior. Pray, Sir, were you told that the Places they digged Salt out of became replenished afterwards with new Supplies?

Chevalier. No; but I make no question of it; for otherwise, by digging for so long a Course of Years, they must long ago have quite exhausted their Stock.

Prior. Not at all for that, seeing the long Continuance of it only proves the vast Abundance of the first Stock, not that it has received any additional Supplies since; for, take my Word, Sir, the Sea does not contribute to the Support of these Mines the least Stream of Water or Grain of Salt, but they consist of Veins or Layers of Salt that have existed in these and several other Places, either since the Creation of the World, or at least since the Time of the Deluge, when the Earth and Sea were mixed and blended together into one common Menstruum: Nay, so far is it from being true, that any Salt-Water comes from the Sea to supply these Mines, that you find, one the contrary, a Rivulet of fresh Water in them, which, beyond all Doubt, does proceed from the Rains; so much as it decreases or quite dries up, according as the Droughts are in Duration or Degree; and after having passed through the Mines, it loses itself under Ground, and runs into the Sea beneath the Surface of its Waters, as I hope to be able to prove to you in some future Discourse. And that those Cavities which have been once dug and propp'd up do not fill again, appears from hence, that they have free Passage out of one into another, and are obliged at certain Times to prop up the oldest Mines with fresh Supporters for fear of Accidents. This has given Occasion to Travellers, who are very much given to the Marvellous, to say, That there was in *Hungary*, above two hundred Fathoms deep under Ground, a Town con-

sisting of several Streets, whose Inhabitants never saw Day-light.

Chevalier. You are very unkind, Sir, to take from me the Argument I most confided in; however I have one more still left, namely, the Salt-Water that they draw from the Wells of *Salins*, which they boil till the Water evaporates, and the Salt is left by itself at the Bottom of the Salt-Pan: Now whence can this Water, that always abounds with Salt, and whose Loss is continually repaired by new Supplies from its Spring, proceed, but from the Sea?

Prior. Though we should concede that the Sea-Water is conveyed into these Wells by a Channel of Communication betwixt the Sea and them, yet you will never be able to conclude from thence, that the Water of the Sea does diffuse itself under Ground in all Parts, and thereby produce fresh Water-Springs; besides, the Waters of *Salins*, as well as those of *Hall* in *Saxony*, and in short of all the Salt-Wells in the World, are nothing else than Rain-Water, after having passed through some Veins or Mines of Salt, that are to be found in several Places within the Earth, which being by little and little washed away and diluted by these Waters, is carried by them into the Wells, from which they afterwards draw it out and prepare it for the Use of the neighbouring People.

Chevalier. If so, these Mines of Salt must in time have been quite exhausted, or at least very much impaired; and the Water, by continually wasting them in this manner, ought to hollow itself a Bed beneath the Bottom of the Well.

Prior. We find it to be so, and at this very time they are obliged to dig much deeper than they did formerly in order to come at the Salt-Water. This is nothing less than Matter of Fact, and it is attested by *Mr. Robault* *.

Chevalier. This Circumstance of the sinking of the Salt-Wells, is a convincing Proof that their Water runs over Layers of Salt, which it consumes by Degrees. Well, I can think of no other Passages, great or small, to convey to us the least Drop of Water from the Sea

* *Physicks, Part 2. Ch. 10.*

either salt or fresh. Let us then see if we can account for the Origin of Fountains some other way than by these subterraneous Conduits; and in the first Place, Sir, pray be so kind as to explain to me how the Vapours that ascend out of the Sea, can supply the Rivers with a sufficient Quantity of Water; for I must confess, that to me the Thing appears almost incredible.

Prior. There are two Propositions that I will endeavour to demonstrate to you; the one is, that the Vapours that arise from the Sea are much more than sufficient to supply both the Surface of the Earth and the Rivers with Water: The other, that the Mountains do by their particular Structure and Formation attract, and, as it were, arrest the Vapours and the Rain that fluctuate about in the Atmosphere; and having collected them in their Reservoirs within, dismiss them again through their Sides, either in perpetual or intermitting Currents.

But it is impossible for me to give you an exact Idea of the Mechanism of Mountains, without bringing you acquainted with their Structure within. As you are light and nimble, it will not be a great deal of Trouble for you to take a little League's Walk To-morrow, up to the Top of those Eminencies you see yonder; we shall there find some Springs, the Situation of which may give us some Light into the Question we are discussing; we shall also see several large Caves made by the falling in of the Earth, which, by giving us a View into the Inside of the Mountains, will discover to us the Order of those different Layers or Strata of Earth that compose the whole Mass. By these means, I don't doubt but I shall thoroughly acquaint you with the Nature and Origin of Fountains, which seem so greatly to excite your Curiosity.

The ASCENT of VAPOURS from the SEA.

MOUNTAINS.

DIALOGUE XXI.

The PRIOR and CHEVALIER.

Prior. **A**S I design to make Mountains the Subject of your present Day's Entertainment, I think I cannot take any better Method to excite your Admiration, than by first convincing you of the surprizing Usefulness of them; for though the Advantages we receive from the Mountains are not like those of the Sun, evident and conspicuous to every Eye, yet their great Utility, if less sensible, is not less real and certain than that of this glorious Luminary: But because every one does not perceive it, several dispute it; and though they continue daily to confer new Benefits upon us, we find People that look upon them as so many shapeless Protuberances scattered up and down the Surface of the Earth at random, without all Design or Intention to produce any good Effect. I doubt not but you will conceive a quite contrary Opinion of them, after I shall have proved to you, that without the Aid and Assistance of Mountains, both Animals and Plants must die for lack of Moisture; that their Summits are designed to stop and collect the Vapours that fluctuate in the Atmosphere; that the intermediate Spaces betwixt their Summits are so many Basins prepared to receive the condensed Vapours and Rains that fall into them; that their Bowels are so many common Store-houses or Reservoirs of Water for our Use; and lastly,

lastly, that those lateral Orifices through which the Waters issue out, are situated in such a manner, with regard to the Plains, that they may descend upon them, and fertilize them, instead of returning by Passages under Ground to the Sea, after having performed an unprofitable Circulation.

Chevalier. That the Situation of Mountains is well contrived for the Descent of Waters upon the Plains, is very evident, and cannot be denied ; but the great Difficulty lies in proving, that there does arise from the Sea a sufficient Quantity of Vapours to supply the River *Seine* alone every Day with two hundred eighty-eight Millions of cubick Feet of Water.

Prior. Whilst we are walking to the Foot of yonder Mountain, the Structure of which we are going to examine into, we may employ ourselves with comparing the Quantity of Water which rises in Vapours from the Sea, and afterwards falls down in Rain to water the Earth, with that which runs through the Channels of our Rivers : And herein I shall fulfil my Promise that I gave you Yesterday, which was to demonstrate to you in the first Place, that the Quantity of Water that proceeds from the Vapours does very much exceed that which is discharged every Day into the Sea through the Mouths of Rivers. We will afterwards proceed to consider the Manner in which the Waters are collected in the Reservoirs of the Mountains.

Some very judicious Persons * have been at the Pains to make an exact Computation of the Inches of Water that might fall upon the Earth in one Year. This Experiment they made by placing a Vessel, at a proper Distance from any † Building or Eminence, to receive the Rain ; and they observed for several Years together, after every Shower, the Height of the Water in the Vessel : then by adding together the several Heights of all the Water that fell in one Year, they found the Amount of all the Sums, at *Paris, Lisle, London, Zurich, and Amsterdam*, to be sometimes nineteen Inches, sometimes

* *Mr. Mariotte on the Motion of the Waters.*

† *To prevent the falling or dashing in of any Water from the Tops or Sides of them.*

twenty, or one and twenty, seldom more, and seldom less, except in very dry Years; so that we may fix the Height of all the Rain-water that falls upon the Earth in one Year at about 20 Inches, taking this for a common Standard, or Medium betwixt more and less.

Chevalier. How, Sir! If all the Water that runs in the Rivers of *France* in one Year's Time, should descend in Rain upon the Surface of the whole Kingdom, do you think it would not overflow it to above the Height of twenty Inches?

Prior. I will immediately prove to you, Sir, that it would fall far short of it. A cubick Foot of Water is nearly equal to 35 *Paris* Pints; now, after knowing this, it is an easy Matter to compute how many cubick Feet and how many Pints are contained in one square * Toise of Water 20 Inches in Depth, and then to divide it into Hogsheds. These Things being premis'd, they cast up how much Rain-water would fall upon an Extent of Ground 60 Leagues long and 50 broad, from the Source of the River *Seine* to within some few Leagues of *Paris*, † including those Lands which are watered by the Rivers *Armençon*, *Jonne*, *Loin*, *Aube*, *Marne*, and some others that send their tributary Supplies into the Bosom of the *Seine*; and they found that the Sum total of all the Rains that would fall in one Year upon that Extent of Land, would amount to 714150000000 cubick Feet: Hence you may judge, what the whole Number of cubick Feet would have been, had they taken the Depth of the Rain at 20 instead of 15 Inches.

After having computed the Quantity of Rain that is to supply the *Seine* with Water, their next Business was to measure the Water of the *Seine* itself, in order to come at the Excess of the one above the other; and for

* A Measure containing six Feet.

† A Toise of Land would receive in one Year 45 cubick Feet of Water at the Rate of 15 Inches high; a League, as it contains 2300 Toises in Length, would be in Square 5290000 superficial Toises, which multiply'd by 45, give 238050000; 60 Leagues multiply'd by 50, give 3000 superficial Leagues; which being multiply'd again by 238050000, the Product will be 714150000000; so that the Land which supplies the *Seine* with Water at *Paris*, receives every Year 714150000000 cubick Feet of Rain-water, allowing no more than 15 Inches for the Depth of it.

this

this Purpose Mr. *Mariotte* made Choice of the *Pont-Royal*, or *Royal-Bridge*, through which, at every given Time, a certain Quantity of this Rain-water must pass; he then set himself to find out how much Water ran under the Arches of this Bridge in a Minute; the Breadth of the *Seine* before the *Louvre* is 400 Feet, the mean Depth of it five Feet; I say, the mean Depth, because it is more than five Foot deep towards the Middle, and less towards the Sides; now 400 multiply'd by five, give two thousand. The Method he took to find out how far these 2000 Feet of Water travelled in one Minute, or the sixtieth Part of an Hour, was by casting a Stick into the River, and then making an Estimate of the Velocity of the Water, by the progressive Motion of the Stick that floated down with it; hence he found, that the Water when high, and the Current strong, did visibly travel from the Arches over 250 Feet of Ground in one Minute; but as it moves slower near the Middle than at the Surface, and much slower still at the Bottom, where its Motion is retarded by the Friction of the Earth; and whereas when the Water is very low, it travels very little more than 100 Feet in a Minute, even at the Surface, and consequently not so far near the Bottom; we will therefore suppose its mean Velocity, instead of 250 Feet, to be no more than 100 Feet in a Minute: it will follow then that the 2000 cubick Feet of Water, which are at any given Time under the Arches of the *Pont-Royal*, will in one Minute's Time have passed beyond it 100 Feet, being succeeded by as many times 2000 Feet of Water as they have travelled over Feet of Ground in that Time.

Chevalier. This is evident.

Prior. We suppose them now, as I said before, to have travelled over 100 Feet of Ground.

Chevalier. Very good; then there will have passed thro' the Bridge in one Minute's time, a hundred Times 2000 cubick Feet of Water.

Prior. Multiply then two hundred thousand cubick Feet of Water by sixty, the Number of Minutes in an Hour, and the Product will be twelve Millions; which being again multiply'd by 24, the Number of Hours in a natural Day, will give two hundred eighty-eight Million cubick Feet. Compare then the Sum total of the Rain-

waters

waters that fall upon all the Lands adjacent to the *Seine* above *Paris*, taking the Height of them only at 15 Inches, with the Sum of the Waters that flow thro' the *Pont-Royal* in one Year ; and you will find the Quantity of the former to be six times greater than that of the latter, there being 714150000000 cubick Feet of the Rain-Water, and only 105120000000 cubick Feet of the *Seine* Water.

Chevalier. Indeed, according to this way of Reckoning, the Rain is much more than sufficient to feed the Rivers ; but I cannot forbear apprehending some Fallacy in the Account, and that Mr. *Mariotte*, fearing lest the Water of the *Seine* should play him a slippery Trick, has played booty with his Arithmetick, and made it run slower through the *Pont-Royal* than it really does ; he allows that the Water at the Surface, sometimes runs 250 Feet in one Minute ; but then by reason of the Decrease of the Water at certain Times, and the Friction of the inferior Columns of it against the Bottom, he cuts off at one Stroke no less than 150 Feet, which I think is too great a Defalcation by far ; and consequently if a much greater Quantity of Water flows along in any given Time than he allows in his Account, his Calculation does not prove what he would have it.

Prior. O ! Sir, I will not stand with you for a little Water ; you shall have all reasonable Measure allowed you : Instead of running 100 Feet every Minute, we will say 200 ; instead of twelve Million cubick Feet *per* Hour, flowing through the Arches, take 24, which is just double the Quantity : I say, after making you this Allowance, the Rain-water, which was six times more in Quantity than the first Sum total of the *Seine* Waters, will be still double, nay, triple of the latter. But what will you say then, if instead of 15 Inches of Rain-water, we take it at the Height of 18 or 20 Inches, which is the common Standard ?

Chevalier. I submit, Sir, and confess that you have fully satisfied me that the Rivers may be supplied with a sufficient Provision of Waters from the Fogs, Snows, and Rains that fall upon the Earth. But there are still some Difficulties that occur to me, which I must beg the Favour of you to explain. If the Earth receives a greater Quantity

tity of Rain than it discharges into the Rivers, pray, what becomes of the Remainder?

Prior. The Overplus, which is very considerable, serves for the Drink of Animals, and for the Refreshment and Nourishment of Plants. The whole Earth is covered with Plants, that, in the Day-time, suck in through their Roots the Water that is diffused under Ground, and sip by Night, through their Leaves, the Moisture of the circumambient Air. I will leave you to judge of the Expence of Water that is necessary for the Support of the whole vegetable Creation, by the Quantity that is required for that of a single Plant. Mr. *de la Hire* put two Fig-Leaves into a Phial filled with Water, and he observed that in less than six Hours, they sucked in the 64th Part of the Water; at this rate therefore, they would have drunk up a 32d Part in 12 Hours, a 16th in one Day, an 8th in two Days, and the whole in sixteen.

Chevalier. I was before impatient to know the Reason why the Sea, which is continually drinking up the Rivers and Brooks that run into it, did not overflow its Bounds, and deluge the Plains; but since I am informed, that the Vapours which it sends to water the Earth, are more in quality than what is repaid it by the Rivers, I long to know, on the other hand, why it does not diminish; for if it goes on to give more than it receives again, it must be exhausted in time, and become quite dry.

Prior. Your Objection, which seems very specious at the first View, will cease to be so, when we come to make a general Calculation of the Quantity of Vapours that rise from the Sea. Let us suppose then, in the first Place, (and one short Survey of the terrestrial Globe will warrant such a Supposition) that the Surface of the Sea is nearly as great as that of the inhabited Land; and let us see in the next Place, whether the Number of Inches of Water that ascend from the Surface of the Sea in Vapours, be more or less in Quantity, than the 18 or 20 Inches of Rain that yearly descend upon the Earth.

If you set a Pan full of Water in the open Air, in very hot Weather, especially if there blows a smart Breeze of Wind, it will lose one Inch in 24 Hours, at other times not more than half an Inch; or if the Weather be very cold,

cold, the Quantity evaporated will not be above a few * Lines, perhaps not discernible. Your Millers, whose Interest it is to keep the Water to a Height sufficient to turn their Mills, and who for that purpose contrive Dams and Sluices to confine it, and to prevent its running faster out than it runs in, observe, that the little Collection of Water which they keep in their Mill-dams, generally loses half an Inch, sometimes a whole Inch in hot Seasons. It is very natural to suppose then, that from all the Seas that lie between the Tropicks, there rises at least, half an Inch of Water every Day, and probably more: But as the Seas towards the Poles may not lose by Evaporation one Line of Water *per* Day, we will set the greater against the lesser; and then may safely venture to fix the Quantity of Water evaporated from all the Seas in a Day, at one fourth Part of an Inch. The *Lamina* or Column of Water therefore, that rises from the Seas in one Year, will be three hundred and sixty-five fourths of an Inch thick; we will say, for the easier way of Reckoning, only three hundred and sixty fourths, which amounts to one hundred and eighty half Inches, or ninety whole Inches. Of the twenty Inches of Water that are detached off to supply the Occasions of our Lands, we have already seen, that not above ten of them are conveyed back again to the Sea, by the Channels of the Rivers; the other ten, after having contributed to the Nourishment of Animals and Plants, return to the Ocean, partly through subterraneous Passages, and partly are carried away by Evaporation, to join the common Mass of Vapours which we suppose still to consist of eighty Inches, at the least, in Depth. We must consider, that as great a Quantity of Rain falls upon the Sea as upon the Land; and therefore must deduct twenty Inches from the Sum total of Vapours upon this Account, which will then still consist of sixty Inches. Now how shall we dispose of this prodigious Quantity of Water that remains, or how be able to reimburse the Sea so vast an Expence? But the Difficulty would be still greater beyond all Comparison, if, besides sustaining the Loss of such a vast Body of Water by Evaporation, it was further obliged to stock the Fountains and Rivers with their or-

* A Line in Geometry is the 12th Part of an Inch.

dinary Supplies of Water through the subterraneous Canals; nay, at this rate it would soon be quite exhausted and dried up.

Chevalier. For Pity's sake, Sir, don't let us impoverish the Sea any more; for I am in Pain enough to think how we shall restore it what it has lost by bare Evaporation, seeing that the Rains, generally speaking, do not refund above one third Part.

Prior. The two remaining Thirds are kept in Reserve for the Wants of the Torrid Zone. In the successive Revolutions that the Sun makes from one Tropick to the other, it would infallibly scorch the Inhabitants upon whom it darts its perpendicular Beams, if Providence had not provided a large Veil or Covering, which seasonably interposes itself betwixt it and them, to shield them from the excessive Heat; insomuch that that Season of the Year, when one would be apt to apprehend their being destroyed by this flaming Luminary almost inevitable, is in reality their Winter, or the coldest Season they enjoy in the whole Year *. At the Time of the Sun's Approximation

The Rains under the Torrid Zone.

* - - - Ubi minimas hic *Phæbus* contrahit umbras,
Nudaque maturis *Æstas* flavescit *Aristis*,
Tunc *Scythicus* Radiis *Taurus* propioribus ictus
Squalientes Tumulos, obfessaque Culmina longis
Frigoribus Cælo ostendit, cæcæque propinquo
Tabescunt à Sole Nives, Glacique solutâ
In Mare spumiferos præceps rapit *Impetus* *Amnes*.
Tum *Nebulam* tenuem & ficci *Spiracula* *Fumi*
Halat *Humus*: tum *Riphæis* erumpit ab *Antris*
Sudificus *Boreas*, Rupesque & Saxa flagellans,
Nubibus æreas nudat squallentibus *Alpes*,
Et *Taurum*, & Mediis insertum *Caucasum* *Astris*;
Nigrantemque *Hyemem*, & piceæ *Caliginis* *Agmen*
In medium cogit Cælum stridentibus *Alis*,
Æthiopumque Solo sitientes irrigat *Herbas*,
Temperat & nimios fecundis *Imbribus* *Æstus*.
Inde ruens præceps altis de *Montibus* *Unda*
Torrentes impellit *Aquas*, *Pecudesque* *Ferasque*
Villarum cum *Strage* trahit; perque *Arva* refusi
Mille Vias pandunt vasto cum *Murmure* *Rivi*:
Quos ubi cæruleum *Nilus* collegit in *Alveum*
Riparum impatiens, latè per *Plana* jacentis
Ægypti diffundit *Aquas*, genaliaque *Arva*

Fœcundat

proximation to the Tropick of *Cancer*, when he advances towards the *Septentrional* Climates, the *Northern* Winds take the Signal, and, as it were at the Word of Command, begin to drive before them the vast Collection of Vapours; which being hurl'd into the Torrid Zone, are immediately condensed by the boisterous Winds; and rushing against the *Abyssinian* Mountains, and those which they find in *India* and other Places, are dashed asunder, and descend in Torrents of Rain for several Months together; which pouring down the Sides of the Mountains into the Plains, at last meet in the capacious Channels of those great Rivers that run a-cross the Countries; hence the River *Indus*, the *Ganges*, the *Niger*, and

Fœcundat *Libyæ* felici Uligine Limi.
 Quoque magis rapido Cælum candescit ab Æstu,
 Hoc magis obscuris vestit se Nubibus Aër.
 Quò magis obliquam feriunt Phœbea *Syænx* (a)
 Tela, minus densâ Cælum nigrescit ab Umbrâ.
 Nec mindis adversâ Mundi Regione remotum
 Cum Sol *Ægocerotæ* (b) tenet, contraria Regna
Æthiopum pluvii Flabris ulescere ab *Austri*
 Credibile est, & Flamina etesa & annua eogi
 Nubila, quâ nimios compescant Imbribus Æstus,
 Quâ Zona occultum se torrida flectit ad Axem.
 Quamlibet hæc firmis astrinxerit Argumentis
 Dia *Pofidonij* (c) Mens, Vis Rationis & Auctor
 Vix paucis fœcere Fidem, *Calaica* (d) donec
 Classis, Iter quærens, nitidis ad Littora Gemmis
 Fœcunda & fuscis radiis propioribus *Indos*,
 Deprendit secreta Orbis, Tenebrisque sepulta
 Eruit, innumeris & Rura habitata Colonis
 Vidit, quâ medium *Phœbi* terit Orbita Cælum,
 Percutit & rectâ subjectas Cuspide Terras,
Tabropanem findens ditem, *Brasiliaque* Arva,
 Arva Voluptati teneræ blandisque dicata
 Deliciis, Cornu quæ Copia larga benigno
 Et Veris genialis Henos fovet; aurea duræ
 Mala ferunt Sylvæ: ridet vestita Colores
 Terra novos; Odor ambrosius de suavis halat
 Floribus, & blandis Volucrum strepit Aura Querelis (e).

(a) An ancient City situated under the Tropick of *Cancer*, betwixt *Egypt* and *Ethiopia*.

(b) *Capricorn*.

(c) A famous Mathematician of *Alexandria*.

(d) The Portuguese Fleet.

(e) *Buchanani de Spæarâ*, lib. 3.

the *Nile*, derive their mighty Stores, and swelling Tides, overflowing the Countries they pass through with Seas of Water, whilst the Inhabitants of these Places that are situated lower than those rainy Regions, sometimes have not a Drop of Rain for whole Years together. What matter of Wonder and Astonishment must it be to them to behold, even at the very Time when the burning Dog-Star rages, their Rivers overflowing their Banks, and the Waters diffusing themselves over their thirsty Plains, and at their Departure leaving a Slime upon them to fertilize and improve them! In like manner, when the Sun has passed over to the other Side of the Equator, and is making its Advances towards the Tropick of *Capricorn*, there are other Winds that blow *à propos* from the Southern Parts of the Earth to the Equator, to the Relief and Refreshment of the Inhabitants of *Guinea*, *Monomotopa*, *Congo*, *Brasil*, *Peru*, and of those that live about the Middle of *America*, bringing in their Stores of Water, which pour down in Torrents into that vast Multitude of huge Reservoirs which are to supply the Rivers *Zaire*, *Oroonoko*, of the *Amazons*, and *la Plata*. These are the chief Rivers that by disemboguing their large Magazines of Water into the Sea, repair the Loss it had before sustained by Evaporation. But if you still make it a Matter of Doubt, whether those continued Cataracts of Rain that descend upon the Countries lying under the Torrid Zone be sufficient to remit to the Sea a Quantity of Water equal to a Body of the same Fluid, sixty Inches deep, extended over the whole Surface of that Part of the Globe, you are to consider that the Rains shower down in no less Abundance upon those Parts of the Sea that lie perpendicularly under the Sun, than upon those Countries that have the same Situation; and therefore it is no Paradox to assert, that sixty or eighty Inches of Rain-water, perhaps much more, fall yearly into the Sea under the Torrid Zone; nor is this at all to be wondered at, when even in *Italy*, at *Pisa*, and in several Parts of *England*, the whole Amount of Rain in one Year rises to forty, or forty-three Inches. Now allowing sixty Inches of extraordinary Rains to fall again into the Sea under the Torrid Zone, besides the thirty Inches common

Derham's Physico-Theol.

to the Torrid, and the two Temperate Zones, the Sea, upon the Balance of the Account, will be found to have lost nothing by Evaporation.

Chevalier. The Sea indeed may easily be repaid by these means. As to what you were pleased to tell me, Sir, of the great Journey that the Vapours of the Sea make, and as touching the Increment of the Waters of the *Nile*, the *Ganges*, and the *Niger*, occasioned by the prodigious Rains that fall within the Torrid Zone, I remember, is confirmed by the concurring Relations of several Travellers that I have read; and indeed it seems to me so plain a Matter of Fact as to admit of no Doubt.

Prior. We are now come to the Foot of the Mountain, and to the Entrance of those Dales where I promised to shew you how the Vapours and Rains insinuate themselves into the Bowels of the Earth, and there form the Reservoirs that feed the Springs. You see how the falling down of the Earth, at different times, and the great Gutters that have been made by the descending Torrents, have laid bare the Sides of the Mountain in several Places; and how steep it is in those Parts where the Violence of the Water has washed away the outward Covering of Earth, exposing to View the sundry sorts of Matter, whereof the Inside is composed. You see likewise just at the Top, under that Coat of Earth that produces a few Thorns and Brambles, a Bed of coarse gravelly Sand, under which you perceive another Bed of grey Sand, which is again supported by one of Stone, beneath which you discern several others succeeding in Order down the Steep towards the Horizon. On the other Side of this Hollow, you perceive a great Number of like Strata, or Layers, lying one above another almost horizontally towards the Top, then bending down and turning up in the Form of a Bow, with its Extremities pointing upwards. It will be needless at present to give you a particular Account of the various sorts of Matter that compose these Strata; that may be the Business of some other Opportunity; it is sufficient for my Purpose at this time to observe to you, that every Part of the Globe, whether you dig into the Mountains or Plains, consists of nothing else than broad Teguments or Strata of Earth laid one above

above another. The numberless Benefits that result from the Nature of this Structure, we will leave to the Examination of any other Time when you shall think fit ; and will set apart this Day for considering that wonderful Contrivance and Design that appears throughout this whole Piece of Workmanship, which, by collecting the Vapours and Rains that filtrate through it, prepares and distributes, in such great Abundance, a Liquor so necessary to the Refreshment and Nourishment not only of Plants and Animals, but also of Mankind.

Chevalier. Pray, what Connexion or Relation can there be betwixt these Beds of Earth and those Vapours that form the Rain ? Yesterday, after we were returned from walking, it rained excessively hard for above an Hour; upon which I had a Fancy to make an Experiment how far the Rain-water could penetrate into the Earth, and to discover, if possible, in what manner it coalesced and gathered together there, in order to form Wells and Fountains ; accordingly I took a Spade, and opened the Earth in six different Places, both within the Gardens, and without the Castle : I dug also in the Top of a little Eminence adjoining, to see if the more elevated Ground drank in the Water more plentifully than that which lay lower ; in some Places, I found the furthest that the Water had soaked into the Earth to be half a Foot, tho' in most Places it came much short of that Depth. If then the Water, after the most severe Showers, does not sink above some few Inches, it is a probable Supposition, that it drains off into some neighbouring Stream or Rivulet, and so runs into those Rivers that discharge themselves into the Sea ; for I cannot conceive how it can constitute any Fountain, since the Earth admits it to pass no lower.

Prior. The Earth indeed does not every where give free Admittance to the Rain-water, but it does in a great many Places, and that is sufficient for our Purpose ; and tho' we should allow the Manner how it does this to be inconceivable, yet it is not therefore less certain. There are some excessive high Mountains, as the *Cordeliers* in *Peru*, the *Pike of Teneriff*, and several others, upon the Tops of which they find the Air sharper and colder in the midst of Summer, than we do in our Climates in the most severe

severe Frosts; if so, we are not to wonder if the Vapours that are carried to their Summits do there congeal, and cover them with Snow, whilst the Inhabitants at the Feet of these Mountains enjoy a temperate Air, or perhaps endure excessive Heats. At the Roots of those Mountains that are always covered with Snow, such are the *Alps* and *Pyrenees*, we generally find Springs that open in *May*, and cease running in *September*; the Reason is this: whilst the Sun by its Vicinity to the nearer Tropick has sufficient Power to heat the Tops of the Mountains, their Covering of Snow melts and sinks down through the Pores of the Earth, either to the Bottom, or at least into the Bowels of the Mountains, where being stopt by Strata of Clay or Stone, it collects into a Body, and gives Birth to Fountains. On the other hand, when the Sun, by receding towards the farther Tropick, loses its dissolving Power with regard to these Mountains, the Snows cease to melt, and the Fountains to run; several Springs are observed to continue running only during the Heat of the Day. From both these Observations it is certain that the dissolved Snow-water does feed these Springs; and that it sinks a very considerable Depth into the Earth, tho' we cannot discern the Passages through which it percolates.

Another Matter of Fact, no less certain than common, is, that our Fountains and Wells are very low or quite dried up in long Seasons of Drought, and that the return of Rain never fails to recruit or revive them; which is a plain Argument that the Rain-water does find a Passage to them through the Earth; and if we allow, as we needs must, that it does by these means contribute to the Maintenance of some Springs, and to the Restoration of others, it is no difficult Matter to conceive that the Rains are the Origin and first Cause of them.

That the Rain then does penetrate into the Earth, is not to be contested; we will in the next place endeavour to explain the Manner how this is effected.

I. It is a general Complaint in hot Seasons, that the Moles, Worms, Field-Mice, Crickets, and a great Multitude of other little Insects, injure the Ground by boring and digging a vast Number of Holes in it of different
Depths;

Depths ; but upon the whole, instead of being hurtful, they are really beneficial, and the Harm they do this way is amply repaired by those innumerable Inlets which they open for the Rain at those Times when we have most Occasion for it.

II. The Gaps and Chinks that open on the Surface of the Earth in very hot Weather do greatly contribute to facilitate the Passage of the Water to the inferior Strata.

III. Those little Crevices, those Gutters of different Dimensions, the Meanders and winding Passages that we every where find under Ground, serve as so many Conduits to transmit the Water they receive from the Surface to the lower Parts of the Earth.

IV. There are some Sorts of Ground more porous than others, which being sated with the great abundance of Water that soaks into them, and being replete with the Stores that are collected within them, discharge themselves again by a perpetual Current under the Earth into some distant Valley ; for there is such an Harmony and Intercourse kept up betwixt the different Parts of Nature, that those which seem most remote and independent one of another, are oftentimes those that co-operate most to their mutual Service and Assistance.

V. We must not form a Judgment of the Surface of the Mountains by those of the Plains ; the latter indeed are sufficiently cribrous for the Reception and Transmision of the Water which goes to form those Wells, which by digging we find almost every where : but the Structure of Mountains is quite different ; the Tops of them abound with Inequalities, Cavities, open Reservoirs, subterraneous Grotto's, and gaping, and, if I may call them so, disjointed Cells. Their pointed Summits, that dart up into the Air, arrest the Vapours that fluctuate in the Atmosphere, which being constipated thereby, descend upon them in the different Forms of Snow, Dew, or Rain ; their Cavities receive and contain the melted Snows and

Rains, which then precipitate through ten thousand different Crannies to the Bottom by reason of their Gravity; they easily penetrate through Beds of Sand and lighter Earth, till they are stopt in their Descent by more dense Strata, as Layers of Clay or Stone, where they make their Lodging; then they work a Passage horizontally, or else are forced by their own Gravity through the Sand, till they arrive at the Extremity of the *Stratum* of Stone, or other dense Matter which obstructed their perpendicular Descent, and issue out at the Side of the Mountain into the open Air. Now, according as the Body of Sand it drains through is more or less deep, or the hard *Stratum* underneath more or less hollowed Basewise, to contain a larger or smaller Quantity of Water, so the Fountain that proceeds from it is either intermitting or perpetual.

The Water that issues forth from these Basons or Reservoirs does not, for the most part, spring out with Violence like the Liquor through a Fisset from the Bottom of a Tub; for in the latter Instance, the Liquor, being confined by the Sides of the Cask, presses both perpendicularly and laterally upon the Bottom: whereas the Water that is collected in those vast Receptacles of Sand which God has planted in the Bowels of Mountains presses very lightly, if at all, upon that inferior hard *Stratum* or Bed of Earth that impedes its farther Descent, seeing the Grains of Sand that are interspersed between the Particles of the Water, and do thereby prevent their uniting into one continued fluid Body, do take off the Pressure of one Particle upon another. The Consequence of this is that the Water next to the external Orifice does easily disengage itself from the Sand, through which it filtrates without being violently impelled by the succeeding Fluid, which in like manner follows it, without any other degree of Acceleration than what it receives from its own Gravity, and even that is lessened by the Interposition of every Grain of Sand that presents itself in the Course of its Descent; and thus the whole continues successively to trickle down in the most easy and gentle manner. Nor is this Mechanism of Mountains without its Usefulness and Design; for hereby that over-quick Discharge of the Water is prevented, which would infallibly exhaust the whole

whole Store before it could be recruited by the Return of the Rain, and consequently deprive the neighbouring Inhabitants of those constant Supplies of Water which they stand in need of. What say you, my dear Chevalier? do you begin now to comprehend the Reason and End of those different Layers or Beds of Sand, Clay and Stone, that go into the Composition of Mountains?

Chevalier. Sir, I perceive that what we oftentimes regard as useless, nay sometimes as detrimental, to us, is really that which most contributes to our Use and Benefit. The Sea, notwithstanding all its Salts, is that first original Fountain which serves to quench our Thirst. The Wind, whose rough Blasts we so much complain of, brings us our Vapours from the Sea: The high Tops of the Mountains, which we are apt to look upon as administering to no purpose of Advantage, serve to fix and condense them. The Holes, Caverns, and Crannies that make the Earth, in many Places, look so deformed and frightful, serve instead of so many Pipes and Strainers for the Waters to pass through into the Bowels of the Earth: And those Strata of dense consolidated Matter serve them for a Basis and Foundation. But nothing delights me so much as the Wisdom and Contrivance that appears in those Masses of Sand, which have been placed on purpose in the midst of those Reservoirs, to prevent too great a Profusion of Water at one time, and to dispense it to us with so much discreet Oeconomy.

Prior. This exquisite Order and Disposition of the Parts of Mountains is not a mere Imagination or Hypothesis, like the Doctrine of Filtration, and subterraneous Alembicks; but you have here ocular Demonstration of it*.

Observe that Fountain that springs out of the Middle of the Hill: Underneath it you see a Layer of very dense, compact Earth, whereas that above it is light and porous: It issues out from the lowest Part of the Layer that supports it, which, as well as those that are still

* The Fountains we are going to give a Description of, are near Zurich. The learned Mr. Sbeuckzer has given us the Plan of them, as also the Chevalier Vallisneri.

lower, bends up on each Side of it in the Form of a Curve or half Circle, and consequently does the same in the Inside of the Mountain.

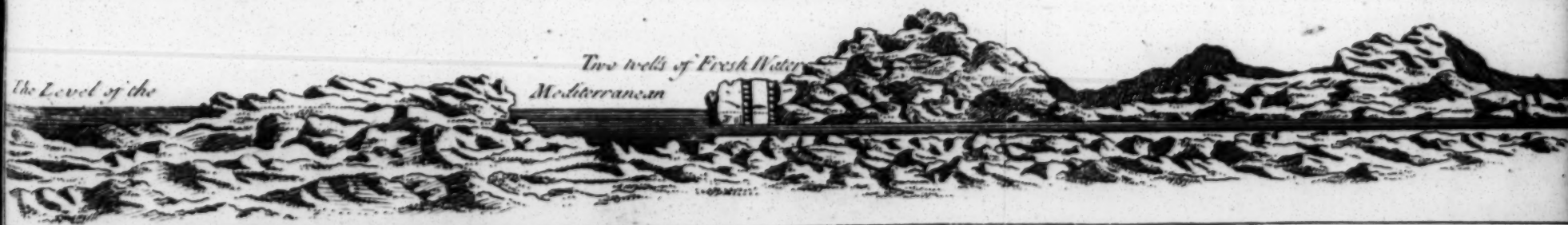
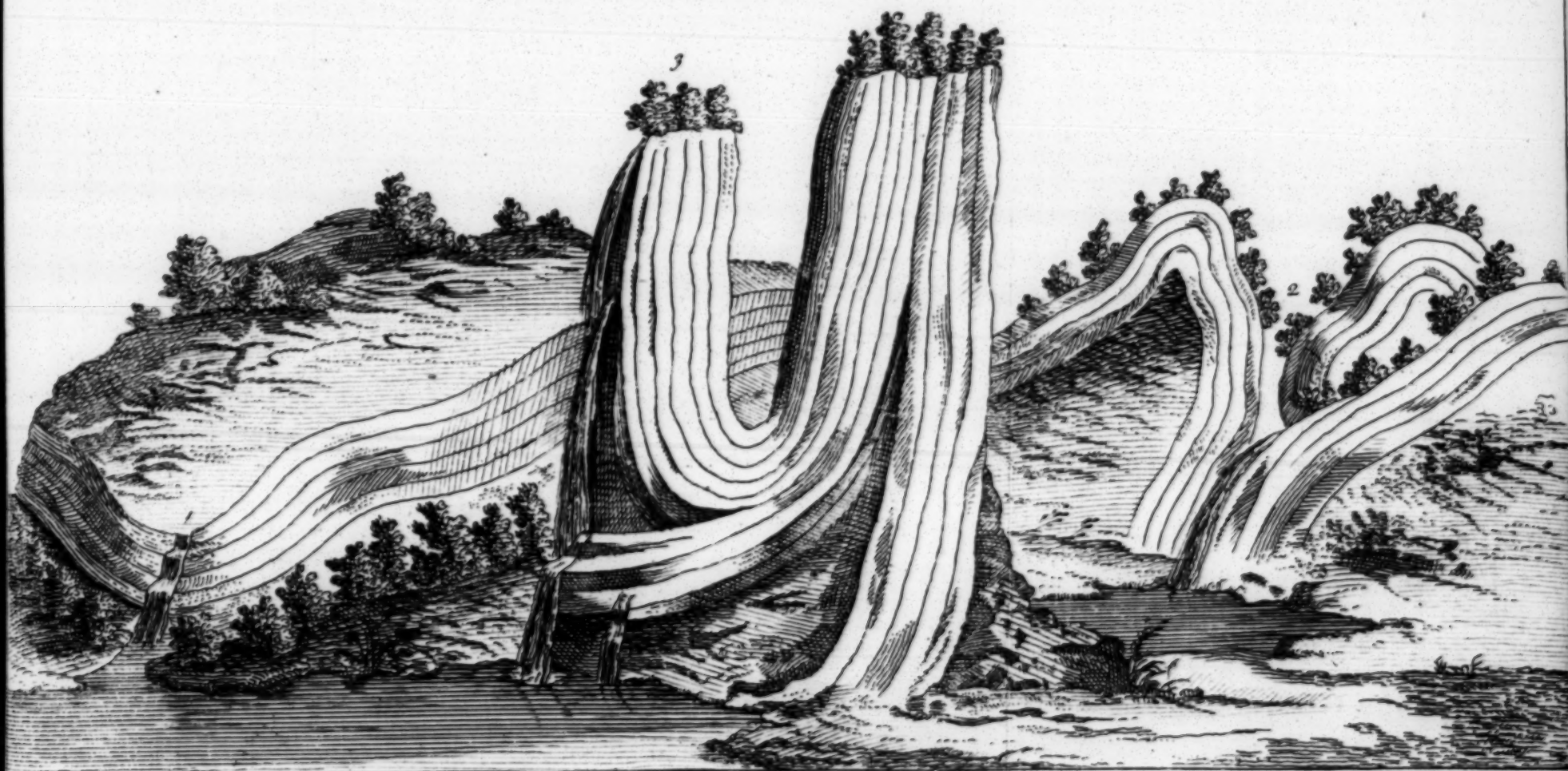
Chevalier. It was certainly designed as a Bafon to receive the Waters that descend through the superior Layers.

Prior. Here is another Fountain that falls from a little Dale above, as situated between those three Eminencies. I have raked into their Summits, and can find nothing but hard impenetrable Strata, which is the Reason that there is no Collection of Waters within them, nor any Fountain springing from their Roots; but instead thereof the Waters that run down their Sides, and from the Thickets that cover them, meet in the little Dale below; the Earth of which being soft and supple, and of a good Depth, they sink in, and break out again in a Fountain, which you see there at the Entrance of that Gut or Opening, which leads up between the three little Hills.

Pray let us go a little farther. You see here four Fountains of a very singular Nature. The first cascades from off the Top of this Eminence, the second from the Middle of it, and the two last spring out at the Bottom.

Chevalier. Pray, Sir, did not you observe to me that there could not be any Source of Water upon the Summit of a Mountain; for that, though the Rain did fall there, yet in order to form any Fountain it was necessary that it should be collected in some Reservoir lower down in the Body of the Mountain? Consequently this Instance makes against your Assertion.

Prior. It is impossible that any Spring should proceed from the Top of a Mountain, unless there be at least some Fathoms of Earth above it, or else some higher Mountains adjoining; in which case the Water that falls upon the higher Mountain, finding a free Passage down into the Earth, rises again in the other, nearly to the same Height it before descended from, as you see the Water in a Syphon ascends up in the second Leg to a Level with that in the first Leg. In like manner, you see on the Side of the Hill from which our four Fountains flow, another higher than it, the Structure of which is in
this



A Subterraneous River n^o runs under the Mediterranean near Frontignan

Tome sculp.

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this manner: All the Strata or Beds of Earth that compose it bend under the little Valley, that divides the two Hills in the form of Curves, several of them rising up again into the lesser. Those Strata which pass from the higher to the Top of the lower Hill convey into it that Water which produces the Fountain of the greatest Elevation. A second Range of Strata that lies lower than the first, and ascends but half way up the second Eminence, produces the Fountain that springs from the Middle; and from the Extremities of those Strata that terminate in the Bottom of the Hill, flow those two Fountains that you see at the Foot of it. So that it is always the Rain that is collected in the Body of the higher Mountain that supplies the four Springs in the lower, by means of those Strata that are continued from the former to the latter under the intermediate Dale, according to the Height to which their different Curves ascend, the Springs there beginning where the Strata end.

It is probably some such-like Structure in the inward Parts of the Earth, that produces such remarkable Effects in the Wells of *Modena*. *Vallisneri Annotationi.* and *Stiria* *. The Workmen begin with digging through several Strata or Soils

till they come to a very hard kind of Earth, much resembling Chalk; here they begin their Mason-work, and build a Well, which they carry on at their own Leisure till they have finished it, without being interrupted by so much as one Drop of Water, and without any Apprehensions of not finding it when they come to make the Experiment. The Well being finished, they bore through the hard Bed of Chalk, upon which the Well is built, with a long Wimble or Auger; but first take care to get out of the Well before they draw it out again; which when they have done, the Water springs up into the Well, and in a little time rises to the Brim, nay sometimes overflows and waters the neighbouring Fields with a constant Stream. Now it cannot be denied that these Waters flow from those Reservoirs that are collected within the *Appennine* Mountains not far from *Modena*, and taking their Course through subterraneous Passages, en-

* See Ray's *Physico-Theol.* p. 39.

deavour to force their Ascent to the same Height they descend from, where-ever they can find Vent.

To the Instances already given, and which carry along with them Demonstration to the very Senses, we will add one of a Mountain that is at a great Distance from any other, and the inward Structure of which has been sufficiently examined into, to gain a perfect Knowledge of the Origin and Motion of the Waters that feed there a large Pond, besides several Wells and Springs. The Mountain I am speaking of is that upon which the City of *Laon* is built. It stands in the Middle of a spacious Plain, that surrounds it on every Side: It is about fifty Fathoms high, and in some Places rather more: It is extended from *East* to *West* about a quarter of a League in Length; then making a semicircular Elbow from *North* to *South*, it runs back again *Eastward* in a Line parallel to the former: But it is necessary to be observed, that this latter Arm is not half so long as the other, and that the Extremity of it is lower than any other Part. The City covers all the first Line, and the Monastery of *St. Vincent* closes the second. The Circuit of the whole Mountain at the Bottom may be about an Hour and a half's Walk. It is not necessary to our present Purpose to be more exact. That Part of the Mountain upon which the City is built, is pretty broad towards the Extremities, but grows much narrower towards the Middle. The whole Town is paved, though several large Places which are on the other Side of the Citadel, and below the Abbeys of *St. Martin* and *St. Vincent*, are not. It is more or less upon a Declivity in every Part, and the Sides are covered with Vines. So much for the Description of the Outside of the Mountain; let us now take a View of its Inside.

The first *Stratum*, or Tegument, is a light Sand mixed here and there with hard Stones. It is of a different Thickness in different Places, being in some twenty Foot deep, in others twelve or thirteen, a little farther perhaps not quite four, and where the Surface is lowest, as towards the Middle of the Town, it decreases to nothing.

The second is a Layer of Rock that extends from one End of the Mountain to the other; and this is double, being parted only by a Bed of Sand or soft Stone: Be-

twixt

twixt these two Layers of Rock they make their Cellars, by digging the Sand or soft Stone out from between them ; towards the *East* they sometimes find nothing but one hard solid Rock twenty or five and twenty, and sometimes thirty Foot deep. Let it be remembered by the way, that this Rock is crack'd and broken in a thousand Places.

The third *Stratum* or Layer, which lies immediately under that of Rock, is a sort of very hard brown Free-stone, not above an Inch thick ; though in some Places this is not found.

The fourth is a Bed of Sand six or seven Foot deep in some Places, in others eight or nine.

The fifth is that *Argilla*, or close-compacted Earth. that is found at the Bottom of the Wells, Fountains, and Pounds, that are dug in the Garden of the *Benedictines* of *St. Vincent*. In this *Stratum* it is that they dig the Vases of their Wells, for the Water to drain into from the neighbouring Sands ; and if it sometimes happens that some Wells shall be quite dry, whilst others at a little Distance from them abound with Water, the Reason is, because this Bed of Earth does not run in a perfect Level, but rises and falls at different Distances ; so that when the Base of a Well happens to be situated in a concave Curve or Hollow, whilst there is any Water in the Sands, it will not fail running into it ; if, on the other hand, the Foundation of the Well lie on a Convexity or Rising of this hard Earth, when the Water in the Sand diminishes and sinks below the Summit of the Convexity upon which the Well is built, it must necessarily dry up in a very little time, and cannot receive any fresh Supplies, till there is a new Collection of Water in the Sands that are situated above the Bottom of the Well.

The sixth is a Layer of white Sand here and there mixed with Shells. The Strata that lie beneath these the Workmen are not acquainted with, they not having any Occasion ever to go lower than the Bed of hard Earth or Clay aforementioned.

Having thus explained to you the Order of those Strata that lie one below another, from the Top of the Mountain of *Laon* to about one third Part of its Depth, let me ask you, my dear Chevalier, whence you think those

Waters proceed that are found upon the Layer of *Argilla* or Clay: Do they spring from below? If so, we must in all likelihood be obliged to fetch them from the Sea. Do they come from above? If so, they must necessarily be produced by the Rains, which falling upon the Surface of the Earth, soak through into the Sands beneath, where they are detained, the inferior *Stratum* of *Argilla* or Clay preventing their descending lower. But I will first relate to you two Facts which I believe will help you out a little, and suggest to you a ready Answer.

A Mafcn, who was sent for, to mend the Bottom of a Well that could not hold the Water that drained into it from the Sands, told me that upon Examination he found a Hole or Fissure in the *Stratum* of hard Clay, through which the Water passed, losing itself in the Layer of white Sand beneath. He found the *Stratum* of Clay to be seven or eight Foot deep. He stopped up the Hole, and the Well was cured.

Another Well not yielding any Water was, by Order of the Master of the House *, dug round about, upon which they found nothing but a confused Mixture of several Sorts of Earth blended together, occasioned by the falling in of the different Soils upon the Layer of hard Clay when they first dug the Well. To repair therefore the Damage that the Workmen had done by thus disturbing the natural Order of the *Strata* of Earth, he caused to be made a Stone-Conduit or Pipe, and to be placed obliquely, so as that one End should terminate in the hard Clay at Bottom of the Well, and the other in a Bed of Sand that was above five Fathoms distant from it. By means of this Expedient there being a Communication betwixt the Layer of Sand above, and the Well beneath, in two or three Days time it was full of Water, and continued so ever after. Tell me now whence you think proceeds the Water that feeds the Pond, the Fountains that issue from the Sides of the Mountain, and all their Wells.

Chevalier. The great Care that the Workmen take not to pierce through the Layer of hard Clay, but to keep every Chink and Cranny in it well stopped up, is a

* *Mr. Bellotte Treasurer of France.*

Demonstration that we are not to look for the Origin of the Water below that *Stratum*, but above it. The Pond which is in the lowest Part of the Mountain, in the Garden of the *Benedictines*, is doubtless supplied from the same Source with the Fountains that flow from the Sides of it, and those which are of the same Height; and the Water of these, as well as that of the Wells, does, in all Probability, proceed from the Rains that soak through the upper Layers into that of the Sand, where they are supported by the Coat of hard Clay. But there remains one Difficulty that I cannot easily get over, that is, how the Waters can penetrate so deep into the Mountain. The Pavement of the Town must necessarily cause the Water to run off down the Sides of it; and will not the Grass that grows in those Places which are not paved be sufficient to choak up its Passage? Besides, how is it possible for the Water to force its way through that Floor of Rock that reaches from one End of the Mountain to the other? This seems to me an insuperable Objection.

Prior. It is true, the Pavement may have lessened considerably the Quantity of Water both in the Wells and Fountains; and a certain Author that wrote about the End of the seventh Century, which was long before the Custom of paving our Towns was known in *France*, tells us, that there were a little below every Gate of *Laon* a copious Fountain, and a Watering-place; whereas there is but one of these at present, and that on the Side of the Citadel, and not above two or three Fountains, and those not yielding much Water.

As for the Turf that covers those Places that are not paved, it may indeed hinder the Water from soaking in every where alike; but it will be sure to find, nevertheless, a vast Number of little Holes and Openings that have been made by different sorts of Animals, or else some Fissures and Chinks that convey it in winding Channels under the Earth into the Bed of Sand.

As for the Rock, you may remember that I told you before, that it is broken and split in many Places; and this appears from Water's running down into the Cellars that are made under it, inasmuch that they are obliged to stop up carefully every Cranny, and to support even the very

Rock itself with strong Piles, lest they should give way, and let the Foundations of their Houses sink down into their Cellars.

Chevalier. These Passages indeed will thoroughly do the Business; and I can now easily conceive how the Rain-Water may pass from the publick Squares, Courts, and Gardens, through these Fissures into the Earth, and so from one Layer to another till it comes to that *Argilla*, or hard Clay, which serves as a Foundation to the Pond, the Fountains and Wells. But there seems to be this Inconvenience arising from hence, that the Drains and Sinks that they are obliged to dig pretty deep under their Houses, must greatly injure these Waters.

Prior. For that very Reason Well-Water is not so good for drinking, except where the Wells lie towards the Extremities of the Mountain, and at a pretty Distance from the main Body of the Town; and in such a Situation the Water of those Springs that run from the Sides of the Mountain is tolerable. But there are also other Waters, that falling down after the Rain on the Declivity of the Hill, there find Interstices through which they pass, descending from *Stratum* to *Stratum* till they come to a Layer of hard Earth at the Foot of the Hill, where they form two Springs * of much better Water than those that proceed out of the Middle of it, by reason of their not having, like them, passed through the Court-Yards and Drains of Houses.

It is Demonstration then to the very Senses, as appears from the View we have taken of the outward and inward Parts of the little Mountain before us, that the Rain-Water does descend very deep in the Earth, and that it is this alone which not only gives Birth to Wells and Fountains, but also feeds and maintains them. Now if this holds undeniably true, where the Narrowness of the Surface, the Thickness of the Pavement, and the Obstruction of a Floor of Rock, all conspire to oppose the Passage and Operation of the Waters, how easy a Matter is it to conceive how this Effect may be produced in those Places where the Earth is very porous, and where there are vast Chains of Mountains that abound with ca-

* The Fountains of *Semilly* and *Bouffon*.

acious Basons and Reservoirs, to feed those Rivers that proceed from them!

But let us still take a farther Survey of the Mountains and Plains, and we shall find, by a few cursory Observations on the different Effects that are produced by the Vapours that descend upon them, so visible a Relation betwixt the Course of these Vapours, and the respective Circumstances and Conditions of Fountains, that I believe it will undeniably appear that the former are the Cause and Origin of the latter.

The Mountains that are within the Torrid Zone receive such a prodigious abundance of Rain at that time of the Year when the Sun is perpendicular to them, that the Quantity of Water which is collected in them is sufficient to raise the Rivers they nourish to the Height, sometimes, of fourteen or fifteen Cubits; so great, for Example, is the Increase of the *Nile* and the *Niger*.

At that time of Year when the Snow that covers the Mountains begins to melt, (for as it hardens in the Winter, so it melts in the Summer) they break out in Springs that continue to flow only till the Snow ceases to dissolve; and consequently those Rivers that are fed by them must be full in Summer, and fail in Winter; and this is frequently observed in *Lombardy* at the Foot of the *Alps* and *Appennines*.

If these Mountains are only covered with Snow in the Winter, the Fountains and Rivers that issue from them swell in times of Thaw or in the Spring, and often dry up in the Summer.

Where the Mountains are only watered with Rain, and not covered with Snow, as is the Case commonly with our Mountains, there, as the Rains are generally most violent, as well as most frequent, towards the latter End of the Summer, and in Autumn, they send forth Rivulets, or Rivers, that are highest in Autumn and the Winter, and lowest in the Spring and Summer.

In those Places where they have no Mountains, the Snow and the Rains are lost in the Earth and in the Rivers, which being increased by these additional Supplies of Water, deposit Part of their Store, as they run along, deep enough in the Earth to form Wells and little Fountains, which again contribute in their turn to

the Maintenance of their proper River, but which grow lower, or dry up, as they fail to receive their usual Augmentation. As for those Waters that soak through the Plains, they feed those Wells that the Inhabitants dig in the Earth to different Depths. The Occasion of the Inequality of their Depths is the Situation of those Layers of the *Argilla* or hard Clay that the Waters rest upon, according to their nearer or farther Distance from the Surface of the Plains.

Chevalier. If this be the Case, we should always be sure to find Springs at the Feet of Mountains, and never want the Convenience of a Well in the Plains; whereas nothing is more certain than that there are Mountains that produce no Springs, and Plains that yield no Wells.

Prior. When the Tops of Hills are covered with Stone, Chalk, or Clay, we are not to expect to meet with any Springs; for the Rain not being able to make its way through these hard *Strata*, runs down the Sides, and loses itself in the Plains, or the adjacent River. So when the Plains are composed of an over-porous Earth, or where there are Fissures and Crannies in the harder Layers of Matter, the Water does there descend so extremely low, as to leave no Possibility of procuring the Benefit of Wells. Such, for Example, is the Country of *Caux*, where there is not so much as one Mountain fit to produce a Spring, nor any Layer of Earth under the Plains close enough to retain the Water that sinks into them; at least, if there be any such, it is so very deep, that there is no coming at it.

Chevalier. I begin to suspect that there may be as much Water under the Earth as there is upon it; for the Rains that fall upon the Plains must there associate into a vast Body; and as there are not always *Strata* of hard Earth in the Mountains fit to retain and stay the Waters that soak into them, they must consequently descend lower down to form great Beds or Reservoirs, which, by reason of their not evaporating like those in the open Air, must still increase, and so in time rise above the Surface of the Earth, and cause a total Inundation. If this be not the Case, pray, Sir, let me know what becomes of these Waters.

Prior.

Prior. This very Objection that you have started will furnish us with a Proof of what has been said concerning the Origin of Fountains.

The Rain-Water that descends through the Mountains and Plains into the lower Parts of the Earth, is there converted into Currents of Water, which are conveyed through subterraneous Channels into the Bosom of the Sea, far below the Level of its Surface. Now if I can prove to you the real Existence of these Currents, I suppose you will allow your Objection to be fully answered.

Chevalier. I will then entirely give into your Opinion.

Prior. The Existence of subterraneous Currents of Water is attested by an infinite Number of Relations, as well as by all those who have wrought in the Mines; but as the Generality of People are of Opinion that they come from the Sea, it will be necessary to shew that they proceed from those Waters that sink through the Surface of the Earth, and that on the contrary they silently glide under Ground into the Sea.

Now that the subterraneous Waters are produced immediately by the Vapours in the Atmosphere, and not by the Sea, will be easily proved. Some *English* Miners *, who were very well skill'd in this Part of Nature, have remarked, that where-ever they found Water under Ground, they had Air also; and that where the former was wanting, they had not enough of the latter to answer the Purpose of Respiration, and that their Lamps went out. Which proves that the same Passages which serve for the Introduction of Water under Ground, serve also as so many Inlets to the Air; and that these Waters come from the Surface of the Earth, and not from the Sea.

Subterraneous
Waters.

The same Miners tell us, that in several Mines at a great Depth under Ground, they have been refreshed with the agreeable Smell of Trefoil-Flower; which may easily be accounted for thus: The Waters, after having fallen from the Mountains, and bathed the Meadows, at that

* *Philosophical Transactions abridged by J. Lowthorp, Tom. 2. P. 372.*

time of Year when they are adorned with Flowers, wash off some minute Particles of their Flowers, which they carry with them through the Fissures and Chinks of the Earth, filling the circumambient Air with the Fragrancy of odoriferous Herbs. Which is another Argument that the Course of these Waters is from the Earth to the Sea, and not from the Sea to the Earth.

In short, we need not have recourse to any more Arguments, to prove the Truth of this Proposition, seeing we have so many matters of Fact, that put it beyond all Contradiction. Several subterraneous Rivers have been discovered to run into the Sea * on the Coast of *Langudoc* near *Frontignan*, as also on the Coast of *Croatia*, over-against *Venice*. And though the Water at the Bottom of the Sea is salted by many Degrees, than that which is towards the Surface, by reason that the grosser Salts always precipitate to the Bottom, (notwithstanding the violent Agitation of the Waters) yet very large Springs of fresh Water have been discovered to rise from the Bottom of the Sea. Now whence can these come, unless from off the Plains? Among the several remarkable Occurrences that were the Forerunners of the Burning of *Puzzolo*, which happened in the Year 1538, an Author † who was then in those Parts relates, that the Sea retired near two hundred Paces from the Shore; that a great Number of Fishes were taken up that it had left upon the Sands, and several Springs of fresh Water discovered bubbling out of the Ground. This Circumstance is not more remarkable than it is demonstrative that these Waters came from some higher Ground. The Diver that went to the Bottom of the Gulph of *Charybdis* ‡ to seek for the Cup that a King of *Sicily* ordered to be cast into it, reported that he discovered large Springs of Water breaking forth with great Violence from the Bottom of the Gulph.

Those Rivers that are so often heard and seen rolling under Ground, and those fresh Waters that discharge themselves into the Sea underneath its Surface, furnish us with a very

The Origin of
the Currents and
Columns of Water
in the Sea.

* *History of the Sea by Mr. de Marfilly.* See the lower Part of the Plate, p. 100.

† *Simone Porzio.*

‡ *Kirker, Mundus subterr. T. 1. L. 2. C. 15.*

plain and unanswerable Reason, why the Rain-waters, that soak down into the Earth, do not swell and overflow its Surface, explaining at once the Regularity of their Course, and the Manner of their Evacuation. From these subterraneous Currents of Water, which after violent Rains roll with a proportionable Degree of Rapidity into the Sea, we may be also able to account for those Currents in the Sea itself, which cross and meet one another in such different Directions; as also for those Mountains or Columns of Water, which are sometimes seen to rise all on a sudden, out of the Middle of the calmest Sea, spouting up into the Air almost to a Level with those Plains from which they came pouring down in Torrents after a Storm.

Chevalier. It seems then, there is a perpetual Circulation of Water betwixt the Sea and the Land. First, the Sea-water descends in Vapours, and then descends in Snow and Rain, either upon the Mountains or the Plains; that which falls upon the Mountains, finds proper Vases or Reservoirs wherein it is collected, thence gently stealing out in Springs, which grow into Rivers, and steer their Course towards the Sea, over the Surface of the Earth, watering the Valleys and Plains as they run along; that which falls upon the Plains, and penetrates deep into the Earth, does likewise return through Passages under the Ground, to the common Rendezvous of Waters.

Prior. This is the Sum and Substance of all that has been said on this Subject; and I believe you are now pretty well convinced of the Use and Serviceableness of Mountains: As for the Rains that descend immediately upon the Plains, they either soon run off them or evaporate, whereas the Mountains feed them with constant Supplies; nor can you be now at a Loss to know whence they derive their Stores, after having learned how the all-wise Creator has contrived such vast Magazines in the Atmosphere above them, from which he showers down his Treasures of Water upon their Summits, which afterwards descending from Story to Story, diffuses its refreshing Streams over the Plains below, gives Life and Verdure to the Plants and Herbs, and beautifies and enriches the whole Earth. You see also at the same time, that Communication that subsists betwixt those Parts of Nature,
which

which before seemed to have no Relation to one another.

When the Almighty, instead of locking up the Sea within the Bowels of the Earth, thought fit to keep it open and exposed to the Action of the Sun and the Winds, by which another Ocean of Vapours might be raised in the Atmosphere no less useful to Mankind, he at the same time raised great Excrescences of Earth, which, to outward Appearance indeed, have neither Use nor Comeliness, but which, in reality, are highly beneficial, as they serve in every Place; as well in the Middle of Continents as Islands, to collect at all times such a Quantity of Water as is necessary to the Formation of those Currents, which are, as it were, the very Bonds of Society, and no less necessary to the Subsistence of Fishes, Birds, terrestrial Animals, and Plants. There is no visible Connection or Relation betwixt the Sea that serves as a Boundary to *France* on the West, and those hideous Rocks of the *Cevennes*, *la Vogue*, and the *Alps*, that are our Limits to the East; and yet this Sea and these Rocks do mutually conspire to furnish us with one of the most necessary Elements of Life. Those little Hills that terminate our View supply us with a crystal Spring, and a very useful Rivulet; but the *Alps* that lift up their lofty Heads betwixt *Italy* and *France*, give Birth to the *Rhine*, the *Rhone*, and the *Po*; and tho' the greatest Part of these Mountains is doomed to an eternal Barrenness, yet to them it is owing, that the Countries on each Side of them exhibit all the Beauty and Fruitfulness of a well-planted Garden. Were the *Alps* and the *Cevennes* away, the *Tesin*, the *Adige*, and the *Po*, would soon dry up, and *Lombardy* become a parched Waste; the *Rhone*, the *Rhine*, and the *Loire*, would disappear, and all the Heart and Northern Parts of *France* be nothing better than a barren Desert. Thus are all the constituted Parts of the Globe mutually serviceable and helpful to each other. The Vapours that are exhaled from the Gulph of *Venice*, and the Coasts of *Holland*, are condensed and collected by turns in the capacious Reservoirs of Mount *St. Gotard*, from whence they are distributed over *Lombardy*, *France*, and *Holland*: The Temperate Zones are fertilized by the genial Warmth they borrow from the Torrid Zone; and this in Return is made habitable



Animals which live in the Mountains

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habitable by the refreshing Vapours it receives from the Temperate Zones. All Nature is linked together by one universal Law of Harmony and Agreement; and as the whole Earth declares itself to be the Work of one only all-wise Creator, so is it no less evident that the Good of Man was the only chief End and Design of his forming it.

After having recounted the inestimable Benefits we receive from the Mountains in those Springs which distil from them, give me leave to add some farther Advantages we reap from them. They are the Refuge of an infi-

Other Benefits of
Mountains.

nite Number of Animals that are of great Use to us, which feed upon them, freeing us from all Care or Charge about their Maintenance, as Bears, Lynxes, Ermines, Martens, Foxes of different Colours, and an Abundance of other Animals, whose Skins make the finest

Furs. Rain-Deer do also live upon the Rain-Deer.

Mountains. These are a sort of Stags which are of extraordinary Service in cold Countries, especially in *Lapland*, where they bring them up to be tame and tractable. The Inhabitants make themselves Cloaths of their Skins, which are very warm, and well covered with Hair; they feed upon their Milk and Flesh; they are also very serviceable in drawing heavy Burdens over the Snow, performing Journeys of twenty-five or thirty Leagues a Day, without any other Provision than Moss for their ordinary Food.

Upon the Mountains that are in warmer Climates, are bred your Bufflers or Buf-

Bufflers.

falo's, which in some Countries they accustomed to draw in the Plough; the Flesh of these Animals they dry in the Smoke, and is used in victualling Ships that make long Voyages. Here also are

bred your *Chamois*, which is a sort of

Chamois.

wild Goat, which skips with great Agility from one Rock to another. The Skins of these Creatures are very good to make Breeches, Stockings, or Gloves of; they are of a lasting Wear, and though as soft and gentle as an ordinary Stuff, will bear washing as often as you please. Nor are Hunters the only Set of Men that pay their Visits to the Mountains, when in Pur-

suit

suit of their Game over the Hills and Dales; but hither also the Herbalists come to seek for wholesome Simples, which either are not to be found elsewhere, or, at least, those that grow here are in greater Perfection, and have a more medicinal Virtue than those we plant in our Gardens.

And as the most deformed and rugged Mountains do answer Ends very beneficial to Mankind, so neither are the most wild, uncultivated Heaths, and barren Defarts, without their Usefulness:

Heaths.

They are like the Shades in a Picture, they give more Life and Strength to the other Parts, and cause them to strike the Eye with double Lustre. When we are situated in the Middle of a rich and delightful Country, where we are presented all around with one continued Scene of Beauties, we are not apt to be so charmed with beholding it; and the Sameness of the Landskip on every Side of it, not only makes the Prospect prove less agreeable, but also weakens those Impressions it ought to make on the Mind, as well as the Sight. We keep our Admiration for what is new or uncommon, and it is not so much the Marvellous as the Novelty in any thing that pleases and awakens the Attention most. When we are surrounded by a vast Number of entertaining and delightful Objects, the Mind is divided among them, and naturally sinks into Inattention and Ingratitude; whereas the Sight of barren Mountains, and parched Heaths, makes us reflect what uncomfortable Quarters might have been allotted us, and how deeply we are indebted to God's free Bounty and Goodness, for the great Blessings of a plentiful Country, and a delightful Situation.

As we return to the Plain, you may observe, my dear *Chevalier*, upon these Hills, among the Herbs that you tread under Foot, a great Number of those that we plant in our Gardens, tho' generally speaking, they derive a greater Fragrancy from these poor dry Soils, and the open Air tempers their Quality in greater Perfection.

Chevalier. I know this Shrub very well, 'tis the Juniper Tree; the Wood of it when burnt in the Fire, yields a delightful Smell, and the Berries of it make a very wholesome Liquor.

Prior. There you see a great many Plants of Marjoram, Balm, and Lavender, all of an aromattick Smell, and very good to make distilled, sweet-scented Waters. I could also, had I Time, shew you Fluellin, Betony, and a hundred other sorts of excellent Vulneraries.

Chevalier. Sir, I am ready to follow you from Plant to Plant to the very Top of the Mountain.

Prior. That would be too much Work for To-day ; though we indeed must allow that Nature has in vain spread abroad her Carpet of healing Plants and salutary Herbs, even upon the very Heaths and Rocks, if we will not be at the Pains to gather or take any notice of them. I have a hundred times heard Gentlemen, Citizens, and Clergymen, when in the Country, complaining for want of Acquaintance, Books, Company, or Employment ; whereas did they but know how to make use of that great Volume that lies always open before them, they would not be alone or without Employment ; and would they but set themselves attentively to read Nature, the Knowledge they would attain to of themselves, would undoubtedly give them more true Satisfaction than what they learn from others. Nature is the best and choicest Library, and the most infallible Counsellor we can apply to in all our Doubts ; for there we neither find Errors, nor different Opinions, nor Controversy, nor Prejudice, nor Contentions ; besides, it is always open, and if we will use our Eyes, we shall be sure to find better Instruction there than we possibly can in Books. But the Misfortune is, that though Nature is so easy of Access, and may be consulted at any time, we make no other use of it than we do of those great Libraries that belong to certain Societies ; we take a Walk in them, see a fine Collection of Books, and go out again without having read a Syllable in any one of them.

The S E A.

DIALOGUE XXII.

The PRIOR and CHEVALIER.

Prior. **I** Don't doubt, Sir, but you are a little displeased at the Sight of those Clouds that are gathering in the Atmosphere, as they may seem to you to spoil the Pleasure of our Walk.

Chevalier. Sir, they give me no manner of Uneasiness, since I am informed that the End and Design of their rising from the Sea, is to supply our Springs and Rivers with Water; on the contrary, I behold with Pleasure those great Bodies of Vapours winging their Way to carry Refreshment and Fertility to the most distant Provinces, and thus readily executing the Command of the Almighty: Heretofore, indeed, I looked upon them as so many unwholesome Fogs, wandering about at random, without any wise Direction; but now I find they are raised from our Seas to distribute Moisture all over Europe, as the Waters of the *Sarasin*, and of *Marli*, are conveyed to water the King's Gardens.

Prior. The Comparison is very just. But as it is usual, after having seen the * *Tuilleries*, and the Gardens at *Marli*, to make a Visit to the Machine which raises the Water for their Use, (the Structure and working of which is no less curious than the Gardens themselves) so let us at present take a View of that Reservoir, which supplies with Water the vast Garden in which God has placed us, and of the Pump which he has set to Work to raise this Water without Intermission. The Reservoir I am speaking of is the Sea, and the Pump the Air, two

* *The Gardens of the Louvre in Paris.*

copious and noble Subjects. We will begin with the former.

Chevalier. O that we were but near the Sea! They say it is a ravishing Sight.

Prior. It shall not be long ere we make a Visit to it; in the mean time we may amuse ourselves with the Representation of it. We will take a turn in the Gallery, where the Court has a Set of Pictures, in which are exhibited all the most curious Particulars relating to the Sea.

Chevalier. Some Years ago I used to be mightily taken with the Pictures of *Jupiter* and his Eagle, *Vulcan* with his Pincers, *Pan* with his Pipe, and all the fabulous Train of Heathen Gods; but I find these Pieces so very common, that I begin to be tired with them; besides, they convey no useful Instruction; whereas the Pictures before us are Representations of Truth.

Prior. Here every thing you see is a Copy of Nature, and of such things as are of real Concernment to us.

The first Set of Pictures presents us with the different Prospects of the Sea; the second with the Inside and Outside of Ships, and the Instruments made use of in Navigation; in the third are drawn the greatest Part of the Fishes that live in the Bosom of the Deep; and in the last ere displayed Shells and Sea-Plants. We will take a Survey of the Pictures in order one after another.

In this here we are presented with a Prospect taken from one of our Sea-Coasts. The lower Part of the Picture is a Representation of a flat sandy Shore, which is terminated on the Left by the two Arms of a large Port or Haven which jet out into the Sea, upon which you see a Light-House, and the Skirts of a great Town: On the Right it is bounded by a Ridge of steep Hills, and pyramidal Rocks, that seem like the Ruins of some ancient Castles, and which, with the regular Buildings of the Town on the opposite Side, form a very agreeable Contrast. You observe, in Proportion as the Eminences on each Side lengthen and recede from each other, the Trees, Houses, Hills, Bendings, and all other Objects, gradually lessen, and grow more faint, according to the exact Rule
of

Picture I. A
Prospect of the
Sea at Sun-set.

of Diminution in Perspective, by which the Eye is enabled to judge of the vast Extent of that watery Plain which is stretched out to the Extremity of the Horizon, where it seems to coincide with the Heavens. The Sun appears half sunk beneath the Surface of the Sea, and gilds the Prospect with its parting Beams.

This seeming Coincidence of the Sea and Heaven gave Occasion to that Conceit of the Ancients, that the Earth and Sea together formed one flat Surface, which served as a Basis to the great Concave of the Heavens: This gave Birth to those Fables of the Sun's cooling himself every Night in the Ocean, and the Stars rising out of the Waters after the Refreshment of the Day. Reason and Experience by Degrees rectified the Errors of their Senses, and at last, though late, they discovered the Earth to be spherical, and that those Revolutions which they before ascribed to the Sun, the Stars, and all the heavenly Bodies, were owing to its annual and diurnal Motions:

As the Painter can only represent an Object in such a Situation at it may be in at any one Instant of Time, and not as undergoing any Succession of Changes, he has therefore prudently made Choice of the Time of Sunset for the Prospect he has here given us; for then the Sea seems, as it were, all on Fire, and the Beams of that bright Luminary, striking horizontally on its Waters, are reflected in a hundred different Directions, forming a most beautiful Variety of Colours. The Surface you observe is wrinkled with a great many little Waves one behind another, which here and there reflect, first, the Ash Colour, then White, next Purple, after that Green, and last of all a beautiful Azure. Such is the View of the Sea, as represented in this first Picture, when the delighted Traveller walks securely on its Shores, whilst the murmuring Waters gently chafe the Strand.

But the Sea does also put on other Aspects, which have their respective Beauties; for as this fluid Element is by turns subject to every little Impression either from the Current or Winds, which act upon it, sometimes in different, sometimes quite contrary Directions; so accordingly

we

we find it almost perpetually changing its Form. Oftentimes you shall see it from a State of easy Motion, little different from a Calm, all of a sudden grow boisterous, (as you behold it described in this second

Picture) opening its wide Jaws into a terrible Abyfs, or with proud Billows dashing the Face of Heaven; you shall

Picture II. The Sea in a Storm.

see some Waves breaking with great Violence against the Shores, and curling back their Heads again into the Bosom of the Deep, while others meeting with ungoverned Fury dash themselves in Pieces, and whiten into Foam, roaring with dreadful Burst, and striking Terror on the stoutest Heart. In the midst of such Tumult and Confusion, we could expect nothing less than that the Sea should quit its Bed, and deluge the Earth, were it not that the same Hand which lifted up the Waters thereof has set it Bounds that it cannot pass; though its Waters rage and swell, yet they cannot go over them, being ever obedient to the Command of the Lord, * *Hitherto shalt thou come, but no further, and here shall thy proud Waves be stayed.* Accordingly we find that the Sea, when in its most violent Agitation, scarce ever incroaches upon the Shore above seven Feet beyond the usual Water-Mark. Amidst those Mountains of Water you see a Ship that has lost its Masts, in a distressed and helpless Condition: All the Passengers seem lamenting their hard Fate, every Sailor turns pale, and the Pilot finding all his Art fail, with despairing Negligence lets fall his drooping Head upon the Helm. This indeed is a dismal Sight, but yet it engages the Attention of the Spectator, by filling his Breast with a secret and passionate Concern.

The next Picture displays a quite different Scene. Here the Sea has smoothed its rugged Brow, its Waters are hushed and still, and its Surface appears like a

Picture III. A Calm.

glassy Plain reflecting another Heaven with its Sun, its Azure, and its Clouds. This universal Calm invites the Fishes to the Shores, where they sport and play at the Top of the Water. The Fishermen whom you see in their Boats casting and drawing their Nets, and the great

* Job xxxviii. 11.

Swallow. *Hirundo*. King-Fisher. *Alcedo*.

Godwit. *Calidris*. Charleton, *de Av. p. 112*.

Sea-Pie or Olive. *Rusticula marina*.

Heron. *Ardea*. Curlew. *Arcuata*.

Cormorant. *Corvus marinus*.

Diver. *Mergus*.

Puffin or Sea-Duck. *Puffinus*.

Number of Sea-Swallows, King-Fishers, Godwits, Sea-Pies, Herons, Curlews, with many other Sea-Fowls, are all taking the Advantage of the Season, and fishing for their Prey. See how dexterously that Cormorant holds the Fish it has caught in such a Posture as may least incommode its Flight. This Bird may be made tame, and brought to useful Discipline. They put an Iron Collar round the lower part of its Neck to hinder the Fish which it swallows down into its Gullet or great Poke from descending into its Stomach; the Bird being thus ringed goes in quest of Prey, and after having filled his Poke returns to his Master, and disgorges it; who, for his Encouragement, returns him a small Part of his Share. Pray behold that Flock of Divers, some of which you see plunging under Water, others with little more than half of their Bodies in the Water. A little farther you see some Sea-Ducks, some gently swimming along, and steering their way with their webbed Feet, whilst others with their Feet upon the Surface of the Water flutter their Wings, and seem betwixt running and flying.

Chevalier. All these Birds have some particular Colour, Air, or Gesture, that distinguishes their several Species. The Painter has indeed exerted his Skill in the Execution of this third Piece. But, pray, had he any particular Design in giving us a Glimpse of the Moon in its last Quarter, as we see it there represented?

Prior. It being at that time exactly betwixt the Full and New, the Painter could not more properly suggest to us the Time of the lowest Tides, which happen when the Moon is in her first and last Quarter; and this he has done

done completely in presenting us with those Shells, which the Sea, by reason of its greater Recess at those times than any other, is supposed to have left on the Shore.

Chevalier. I have often heard it said, that the Sea ebbs every Day several Fathom, nay above half a League on some Coasts. How may this agree with what you just now said, that in its highest Elevation it did not exceed its usual Water-Mark above seven Feet?

Prior. The Elevation I then spoke of was that of a Sea in a Storm, which is little more than seven Feet above what it would otherwise have risen to. The Flux and Reflux we are now speaking of is quite another thing.

Every Day, generally speaking, the Water of the Ocean, and perhaps that of all other lesser Seas in like manner, though not so visibly, flows six Hours together from South to North, and rises on the Coasts more or less; this we call Flood; when it is at its greatest Height, or high Water, it remains at that Pitch about a Quarter of an Hour, and then retires, continuing to decrease six Hours more; this Return of the Waters from North to South, and from our Coasts to the Ocean, is what we call the Ebb; when the Water is come to its greatest Decrease, or lowest Ebb, after remaining so about a Quarter of an Hour, it makes again to the Land. Now the Tides are always regulated by the Course of the Moon, which Body does twice every Day traverse that Line which we suppose in the Heavens to be extended from the Pole directly over our Heads, and dividing into two equal Parts our Hemisphere, and that which is beneath us: When the Moon is come to that Line which bisects our Hemisphere, and which we call our Meridian, it is then high Water with us: When the Moon, twelve Hours after, or rather more, is come to the same Meridian in the inferior Hemisphere, that is the time of the next high Water. But as the Moon takes up twelve Hours and twenty-four Minutes in passing from the superior to the inferior Meridian, so from the time of high Water to the time of next high Water is twelve Hours and twenty-four Minutes; and consequently the first of every Flood is later than the preceding Flood by twenty-four

Minutes. The Tides rise highest about the New and Full of the Moon, which we call Spring-Tides; and the highest Spring-Tides happen at the Equinoxes. This is undoubted Matter of Fact.

We might next proceed to inquire into the Cause of so regular a Phænomenon; but this is what Philosophers are greatly divided in their Opinions about. Some of them maintain, that the Moon, as it passes over our Seas, does produce this Effect by compressing the Atmosphere which lies betwixt it and the Ocean, and that that Body of Air by its elastick Power endeavouring to expand itself, presses upon the Water, and by the Force of that Impression makes it to rise upon the Land. Others deny that the Pressure of the Moon, by the Mediation of the Atmosphere, has any Share in producing this Effect; but ascribe it to the Power of Gravitation, or a Tendency in the Earth and Waters to approach nearer the Moon.

However this be, we will resign to your profound Naturalists the Province of consulting the Laws of Motion, and the Actions of the heavenly Bodies upon one another, to account for these constant and uniform Revolutions. Let them, with the Line and Plumbet of their Philosophy, take the Distances of the Planets, and calculate the just Proportion of their moving Powers in the different Degrees of their Approximation or Elongation; yet after all their curious Speculations you shall not find two in a hundred of them agree, or conclude the same. The Uncertainty of these Inquiries is sufficient to discourage us from entering into them; therefore, instead of vainly presuming to explain the Mechanism or Manner of those Operations, which are so constantly at Work to produce these regular Vicissitudes of the Flux and Reflux of the Sea, let us endeavour to discover the End and Intention of Providence in this wonderful Oeconomy. To attempt to comprehend a System of Rules and Laws, which perhaps surpasses the utmost Stretch of our Capacities, is nothing less than Presumption; but to lie under a voluntary Ignorance of the Obligations we owe to the Author of that System, is Ingratitude or gross Inattention.

Chevalier.

Chevalier. I perceive you are going to let me see the Benefits which Men receive from the Flux and Reflux of the Sea without attending to them, whilst they unprofitably busy themselves in searching into the Causes of them, which they never yet were able to find out.

Prior. The first Benefit that high Tides are of to us, is repelling the Waters in the Rivers, and causing them to flow back again a great way within their Banks, thereby opening their Channels, and making them deep enough for the carrying up large Ships of Burden to the great Towns, which without this would be impracticable. The Vessels wait in Readiness for the Convenience of this Increase of the Waters, and take the Advantage of that Opportunity to sail safely into the Road, or up the Rivers, without any Danger of running a-ground, or striking on the Sands, for want of Depth of Water. The Tides, having been thus serviceable, decrease, and give the River a free Passage through its Channel, and its Inhabitants the Opportunity of taking the Advantage of its proper Course.

The Usefulness
of Tides.

Another Benefit which our wise Creator designed for Man, by thus exactly balancing the Motion of the Waters, was to prevent their corrupting, and thereby breeding any Infection that might arise from too long a Stagnation of them. He has not therefore committed this Trust to the uncertain Care of the Winds, which though appointed to purify the Air we breathe, and to facilitate the Productions of the Earth by the Diversity of its Impressions and Influences; and though the Winds are not less useful upon the Sea in transporting our Merchandise, with more Ease and Expedition than the best Horses could possibly do by Land; yet as their Blasts are very uncertain, and oftentimes succeeded by long Calms, which would soon breed Putrefaction in the Sea, that great Receptacle into which all the Sinks and Drains of the Earth discharge themselves; God has therefore been pleased to superadd to those irregular and interrupted Purgations of the Winds these diurnal Helps of the Flux and Reflux of the Tides, on purpose to prevent any Contagion or Nuisance that would otherwise arise from such collected

Impurities ; by which means whatsoever Filth or Ordure is carried by the Rivers into the Sea, is so far from accumulating or breeding any Infection, that by the perpetual Motion of the Waters it is dispersed and attenuated, and converted by Evaporation from the Surface of the Sea, into Dews and Rains, which are afterwards changed into the Substances of Vegetables, and the Fruits of the Earth.

But to preserve the Sea more effectually in a constant State of Purity and Wholsomeness, the Flux and Reflux of the Tides are appointed to keep the Waters of it from one End to the other in a continual

The Use of the
Saltness of the
Sea-Water.

Agitation ; thereby stirring up the Salts it abounds with in such Plenty, and which else would soon precipitate. Besides, should the Water on our Shore once lose its Saltness, it would stink, and become abominable, and poison all our Fish, thereby depriving us of one of the most delicate and bountiful Gifts of Nature.

Chevalier. I am all over Gratitude to our kind and good Benefactor, who has thus carefully provided for our Entertainment and Welfare. I have often heard People pretend to explain the Cause of the Saltness of the Sea ; and some Persons, who have the Character of being very profound Naturalists, have ascribed it to some *Strata* or Beds of Salt in the Earth, which communicate under Ground with the Sea, and are wasted away by little and little, by the washing of the Waters. To hear these Gentlemens Philosophy, one would imagine that the Sea becomes salt by mere Accident. As for my part, I am now convinced that it is so by the special Order and Appointment of Providence ; and I do not see but that it is full as ridiculous to ask what gives Saltness to the Sea, as what gives Light to the Sun. God has been pleased to make the Sun a luminous Body, because otherwise it would have been useless to us ; and God has therefore salted the Waters of the Sea, because otherwise, instead of being serviceable, they would really have proved injurious and prejudicial to us.

Prior. I am transported to find that you have so all on a sudden hit upon the Truth of the Matter. However, it may not perhaps be disagreeable to confirm you in
your

your Notion, by offering some new Proofs to convince you of the Reasonableness of it. By the Confession of those very Persons who attribute the Saltness of the Sea to the Extremities of those Beds of Salt which the Water is continually diluting, the Bason of the Sea is allowed to be one continued Surface of Earth ; for under Water, as well as upon the Land, we find Eminences, Plains, and Vallies, Beds of Rocks, Sand, and Earth ; and as upon the Surface of the Land we very seldom find the Extremities of any Salt-Beds, so neither can we suppose them more frequent under Water ; or allowing them that they may generally be met with in the deep Hollows and Cavities under the Sea, yet it is certain that the extreme Parts of these *Strata* do not constitute the thousandth Part of the Surface of the Globe which is under Water ; and this is confirmed by the Soundings of Sailors, who, upon haling in their Line, instead of Salt, generally find Sand, Mud, or Gravel, sticking on the Tallow which is at the Bottom of the Plumbet ; nor is it to be imagined, that the *Strata* of Salt under Water bear a greater Proportion to the other *Strata* there than they do upon the Land, which we are sure is not more than as one to a thousand ; for in digging in the Earth we shall always find at least a thousand, if not a hundred thousand Bushels of Earth for one of Salt. Now by repeated Experiments we know that two Pounds of Sea-Water taken off the Surface will contain one Ounce of Salt, or one thirty-second part of their Weight ; if taken from the Bottom, will generally yield somewhat more : Now if the Salt that is in the Sea is equal in Weight to one thirty-second part of the whole Mass of Waters, I ask how the Extremities of those *Strata* or Salt-Beds, which do not constitute one thousandth part of the Surface of the Sea's Vase, can produce a Mass of Salt equal to a thirty-second part of the whole Mass of Waters ? Besides, we are daily consuming part of these Salts, though we cannot perceive that the Sea loses any thing of its saline Quality. How then does it repair this continual Loss ? Does it take a Journey under-Ground in quest of fresh Recruits ? If so, it must, in so long a Series of Years, have quite exhausted its whole Magazine of Provisions, and long ago become quite insipid. Upon the whole therefore, it is a great Error

to ascribe so constant and general an Effect to so accidental and partial a Cause as that of the Borders of Salt-Beds, or any Veins of it running into the Sea, and which, if it were so, bear so small a Proportion to the thirty-second part of its whole collective Mass of Waters.

God Almighty has been pleased to give the Water of the Sea a viscid and bituminous Quality, to the end that it might discharge a glutinous kind of Matter, which settling on the Bottom, might stop up the Pores of the Earth, that the Water, instead of penetrating and wasting away the Earth, should not be able to dissolve or mix with any part of its *Strata* beneath. He has also made the Water of the Sea salt, that it might always be preserved untainted, and fit for our Use; and we may venture to pronounce of the Brackishness of the Sea-Water, as of the Fishes, to whose Being and Support it is so necessary, that the former was no more fortuitous, and the Work of Chance, than the Formation of the latter was merely accidental. The same Hand that formed the Fishes of the Sea, did from the Beginning prepare for them an Element suitable to their Nature, and intermixed with it those Salts which are so necessary to their Preservation. But how amazing and numerous are the Designs of Providence for our Good in all its Works! This Saltiness of the Sea, which we have already shewed to be so serviceable to us, both in keeping our Waters wholesome, and in nourishing our Fish, is no less serviceable to us upon two other Accounts: First, the smallest Particles of Sea-Salt are exhaled together with the Vapours, carried all over the Earth, and become one of the grand Principles of Vegetation. Secondly, those Grains of Salt that are more gross and heavy, resist the Action of the Sun and Air in rarefying the Waters, and thereby fix the Measure of Evaporation; for the Particles of the Salt and the Water being blended and incorporated with each other, are neither so easily nor so quickly separated; and the more these saline Particles are that obstruct the rarefying Power of the Heat and the Air, the fewer aqueous Particles are raised by them in Vapours. It is the Salt therefore which (by making the Water specifically heavier) moderates the Quantity of exhaled Vapours, and consequently to it we are obliged for that just Proportion of
fresh

fresh Water which the Sun causes to evaporate from the Sea for our Use; for were it not for the Resistance it meets with from these Particles of Salt, it would raise from the Sea a Quantity of Vapours sufficient to drown the Earth, instead of making it fruitful.

After such valuable, constant, and universal Advantages which we receive from the Salt of the Sea-Water, one would be apt to think we had enumerated all the Virtues of it; whereas I have not yet spoken of the principal Use it is of to us. Salt makes one chief Ingredient in every thing we eat, and so tempers and proportions our Food to our Constitutions as to make it nourishing and wholesome; and lest we should be deceived herein, our Taste has a distinguishing Faculty to know in what proportion it is good and proper for us by the Degree of that Savour with which the Salt relishes it: Let us not say then, that because the Sea affords us Salt, therefore Mankind took a Fancy to eat it with their Meat; but rather, that the Reason of the Sea's producing it in such Plenty is our standing so constantly in need of it:

Let us therefore conclude, that the Sea was not at first created fresh, and afterwards changed from its natural State by a fortuitous Rencounter of some Salt-Mines; but that he who formed Man to live upon the Earth, has surrounded his Habitation with this salt Element on purpose to answer his necessary Occasions. And in this, as well as in every other Work of the Creation, we may discern how every Part of Nature, under the Direction of the all-wise Providence of God, does concur, as it were with one common Consent, to promote the Happiness of Mankind. How wretched a Philosophy then must theirs be, who at the same time that they are pursuing the Study of Nature, overlook the gracious Designs of Providence so visibly displayed therein! And such is the Philosophy of those, who instead of referring to God's Wisdom and kind Regard for our Good, those beneficial Effects which continually surround us, ascribe them to necessary and undesigned Causes, or call them the Productions of blind Chance.

Here are other Pieces that present us with the Sea in a new Point of View, wherein the Painter has flung together every thing that relates to Navigation and Shipping.

The first of these is a Representation of the Arsenal of *Rocheport*, where you may see every Particular that belongs to the Fabrick of the largest Men of War, and of Merchant-Ships of all Sorts and

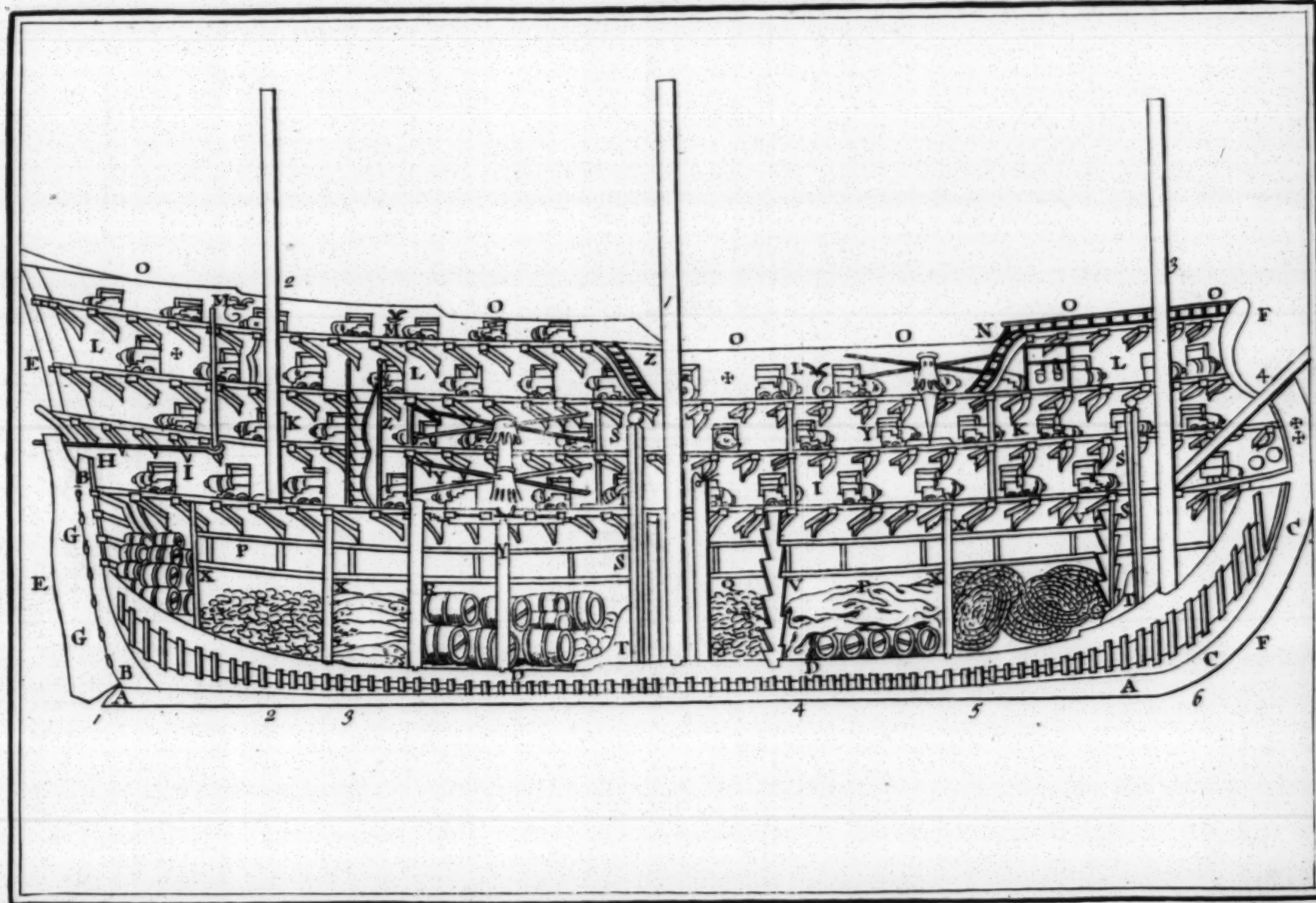
Sizes. That which you see them beginning to build upon those Stocks is as yet but one long Keel, which runs from Head to Stern, and is to keep together the Bottom-part of the Ship. Upon those other Stocks you see the Keel set with two Rows of Ribs or crooked Rasters, which come bending from the Keel like the two Rows of Ribs from the Back-bone in the human Body. This is properly the Shell or Carcase of the Ship. You see there another, whose Ribs are covered over with strong Planks, and which they are now going to launch. They have raised her Stern high, that her Head may lie stooping towards the Sea, and more easily slide upon its Keel along that wooden Trench which incloses it on each Side, and lies sloping down to the Water. This Inclination of the Ship, the Tallow with which they grease the Cradle it runs in, the Force with which Men pull it along by Ropes that are fastened to it, together with its own prodigious Weight, all conspire to give it a rapid, though steady, Motion down into the Water. At present you see it holden back by a strong Cable fastened at one End to the Steerage, and at the other to a Stake driven into the Ground; which the Carpenter, at the Word of Command, has no sooner cut asunder with his Hatchet, than the Ship shoots like Lightning into the Water, and plows up the Waves with her * Prow; then sinking † abaft, she rears her Head again, and recovers her Equilibrium.

Here are some other Ships that are quite finished, and which they are now fitting out. You see here all the Masts standing erect, and the Yard-Arms, to which the Sails are fastened. As for the Number and Use of the

* The Fore part of a Ship.

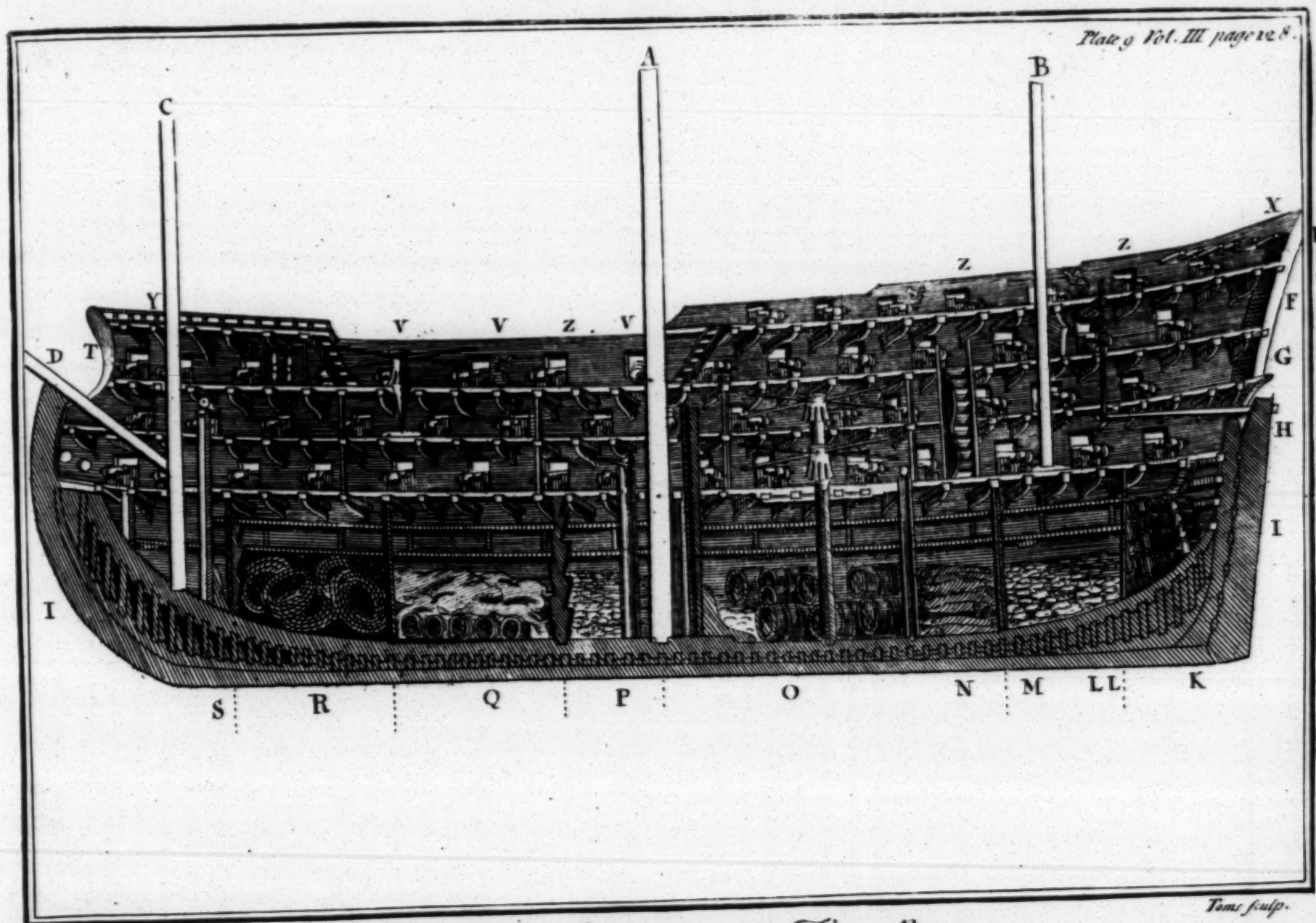
† The Hinder-part of a Ship.

Ropes,



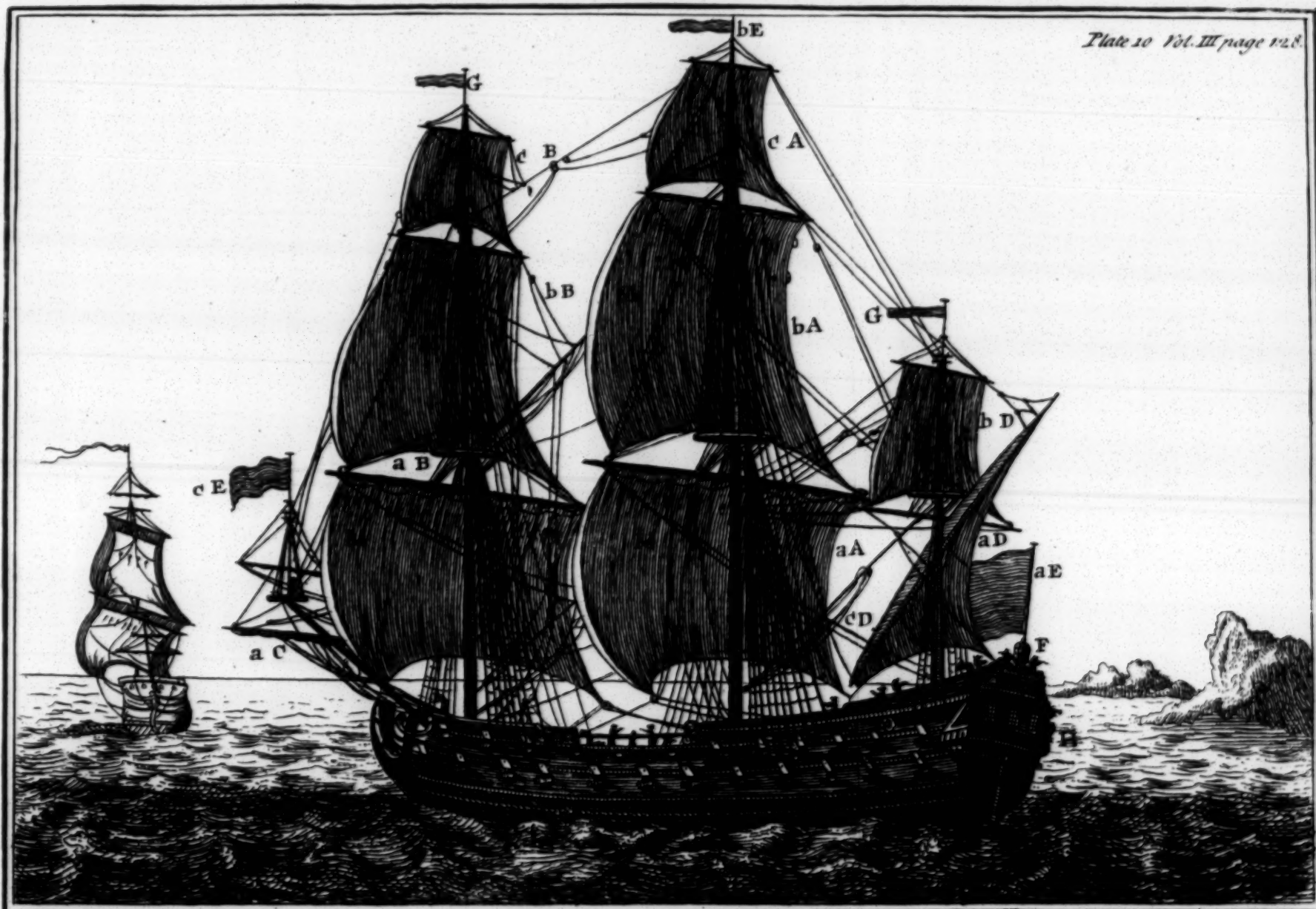
The First Draught of a Ship of the First Rate.

From sculp.



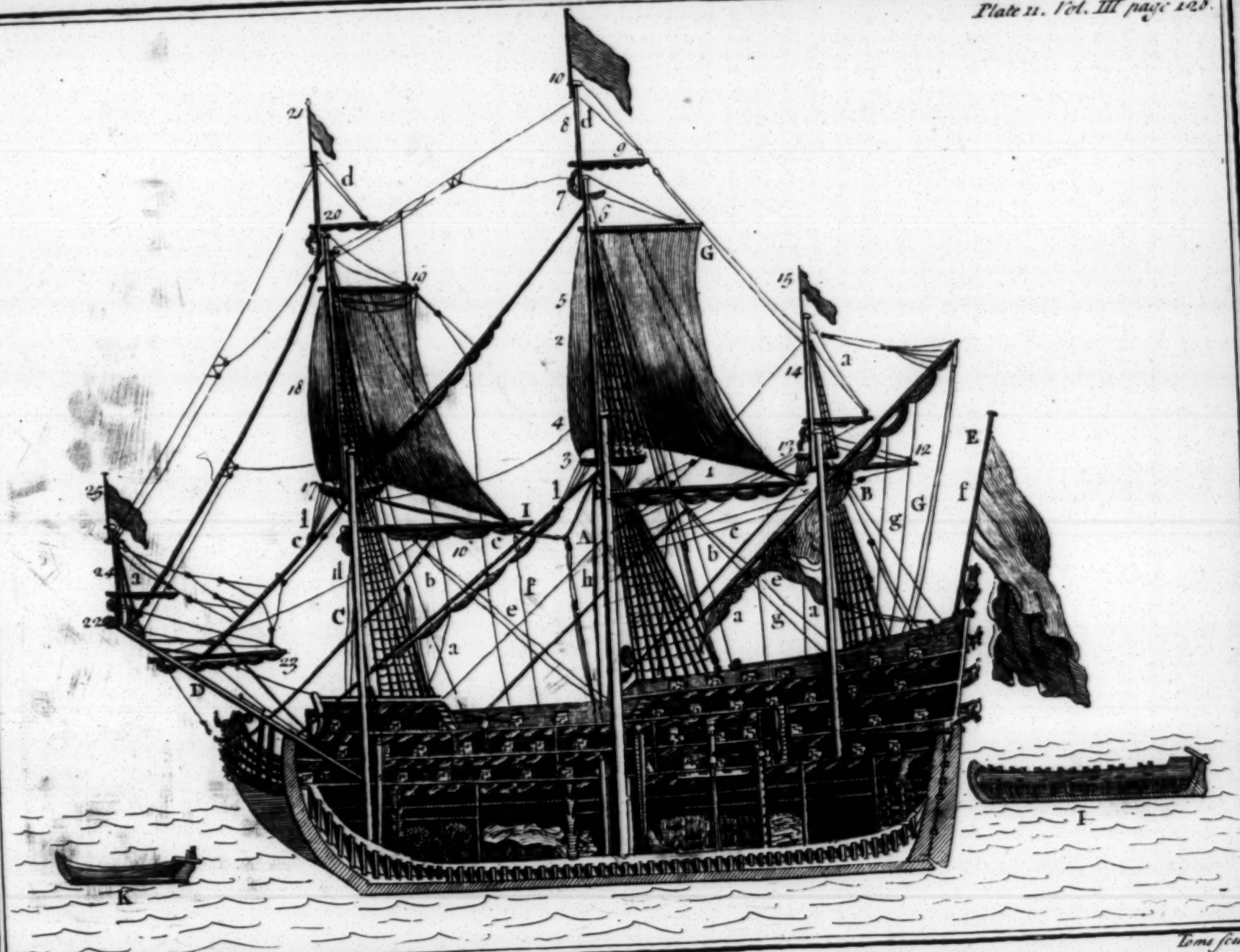
Toms sculp.

The Second Draught of a First Rate



A Ship Carrying all her Sails.

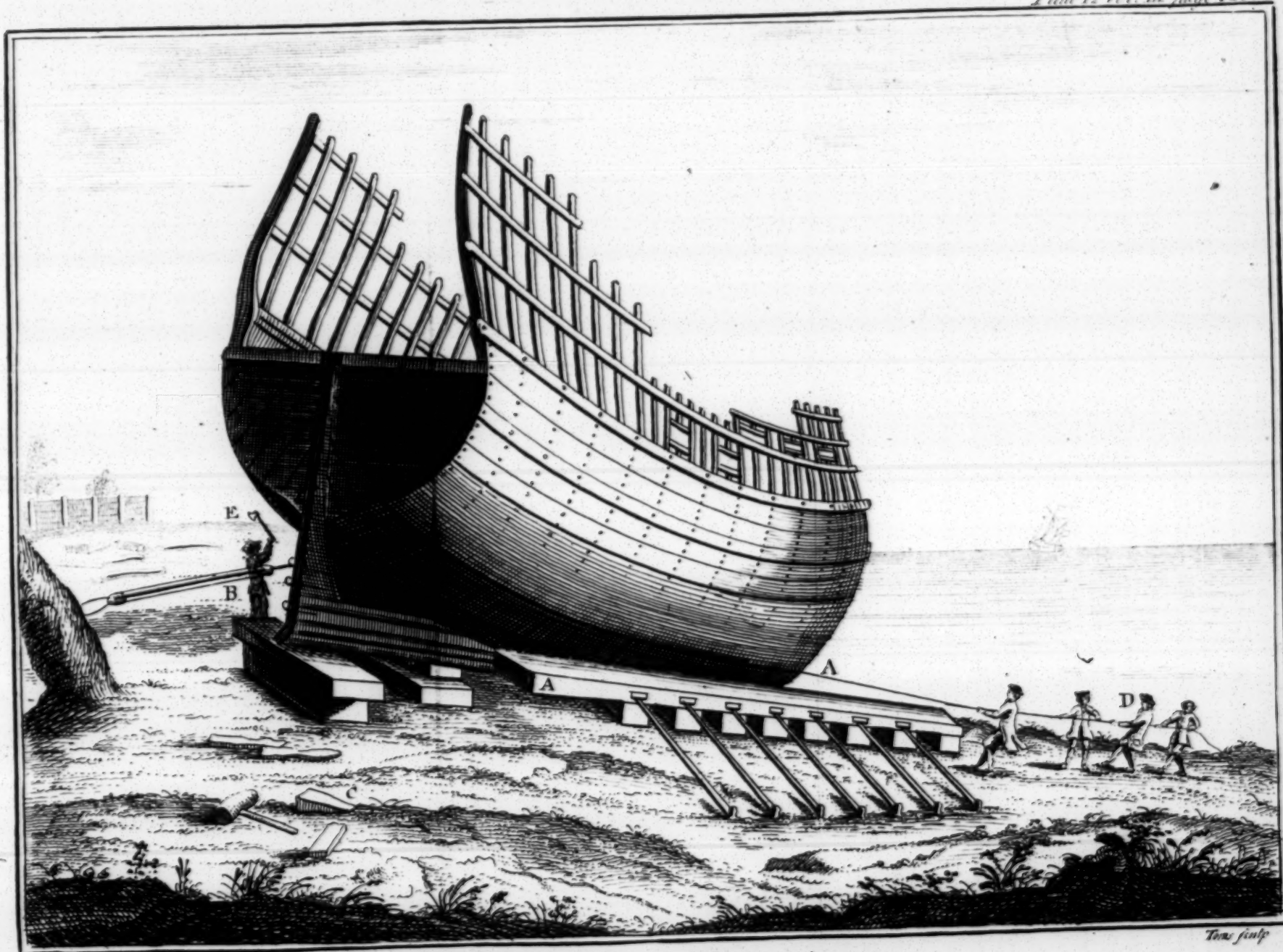
Toms sculp.



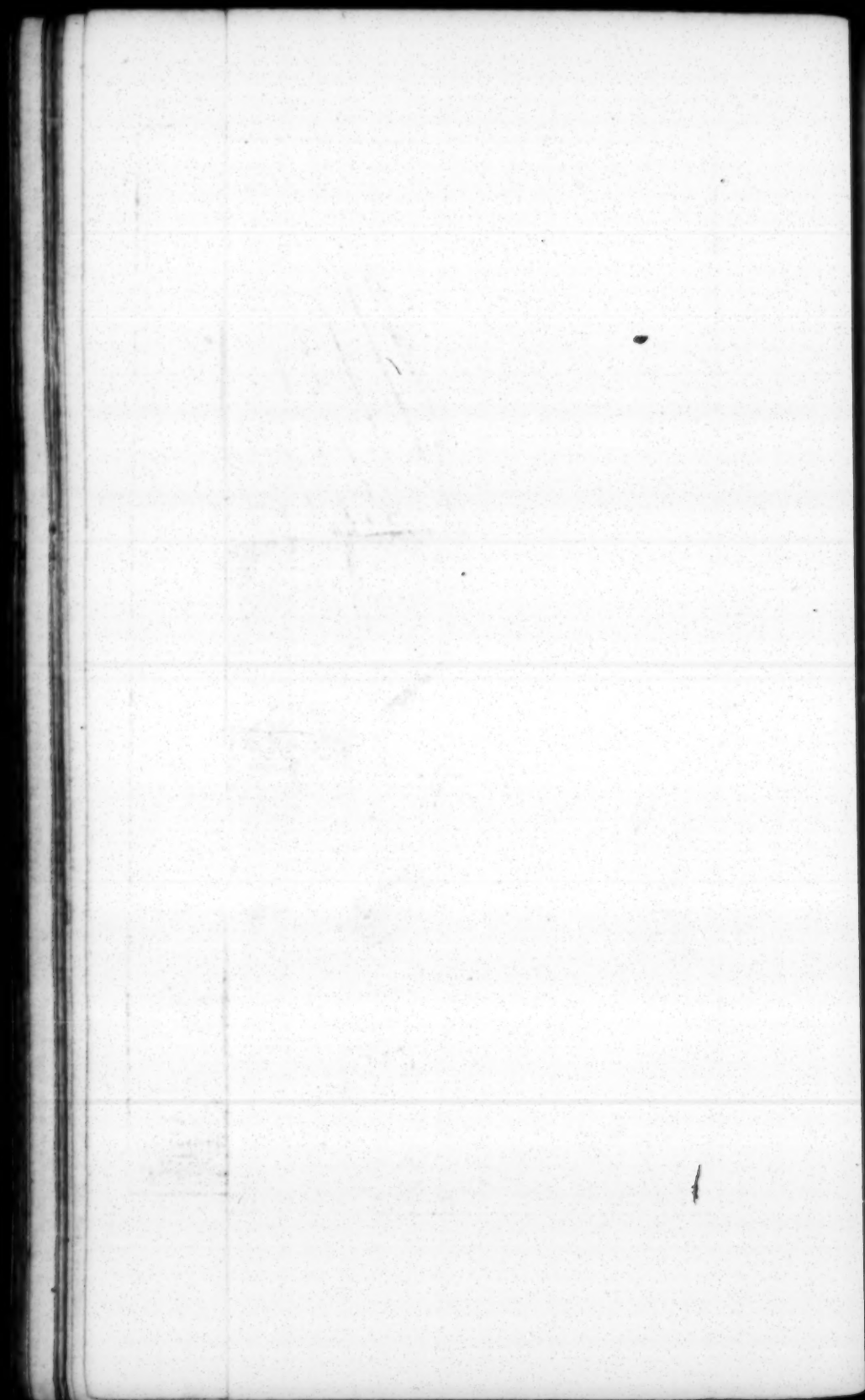
Toms sculp

The third Draught of a First Rate.

11



The Launching a Vessel into y^e Water



Ropes, Cables, Pullies, Platforms, Flags, Anchors, Captain, and of the other Parts of the Rigging; these are things one would be ashamed to be ignorant of, both because they are often mentioned, and easily understood: I will therefore give you the Catalogue of them, as I took it from the Mouth of a very expert Sea-Officer, when we had all these things before us.

Chevalier. There will be Work enough cut out for me against I make the Visit to the Sea which you promised me. But pray, what means that large Roll or Draught, which several People seem looking upon so attentively?

Prior. As the Painter could not possibly describe the Inside of a Ship, he has therefore placed here an Engineer giving Directions to a Master-Carpenter relating to the Dimensions of all the Parts, both within and without, of a large Ship that he has Orders to build; you see the Draught there, which being a Representation of but one half of the Ship you may discover the Inside of it. For Example, that large Space you see there is the Hold, and those three Stories above it are the Decks. The Hold is where they lay in Stones, Sand, and other Kinds of ponderous Matter to serve by way of Ballast, and to keep the Ship steady; what remains of the Hold and between Decks serves for the Stowage of such Goods and Merchandise as the Vessel is freighted with. The Guns are placed upon the Decks, and put through the Port-Holes.

Chevalier. Pray, why have they laid that Vessel on its Side? The People seem to me to be colouring it.

Prior. The Work they are about is called Careening a Ship, or laying it in such a Position, that they may come at her Keel, which is that long Piece of Wood at the Bottom that reaches on the Outside from Head to Stern. And this they do either out of Necessity, or by way of Precaution, either to stop her Leaks, or to prevent her having any: Their way of doing this is by covering those Places that let in the Water with Pieces of Wood, or Plates of Lead, and then calking the Seams and Joinings, that is, ramming them hard with Tow dipped in Tallow and Tar. But the chief Method they use to prevent the Water's soaking through, is by besmearing the Outside of

the Bottom of the Ship carefully over with a Composition of Pitch, Tallow, Train-Oil, and pulverized Glafs.

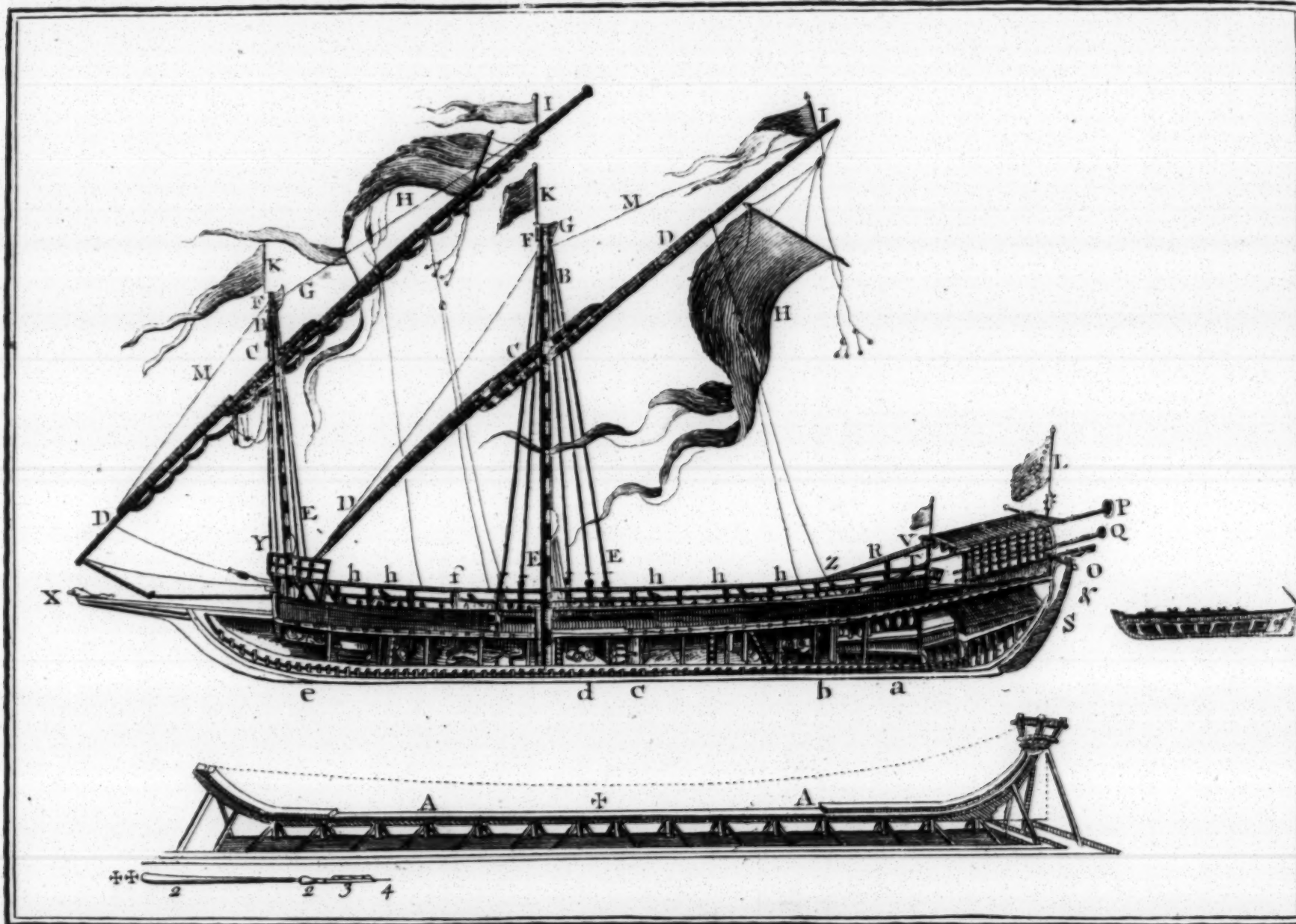
Chevalier. I can easily conceive how those unctuous Bodies well mixed and tempered together can keep out the Water, and preserve the Wood from Putrefaction; but pray, what Use can the pulverized Glafs be of?

Prior. This is one of the wisest Precautions they can make use of to prevent the Worms from eating into the Wood, and thereby giving Admittance to the Water through a thousand little imperceptible Avenues. There

The Pipe-
Worm.

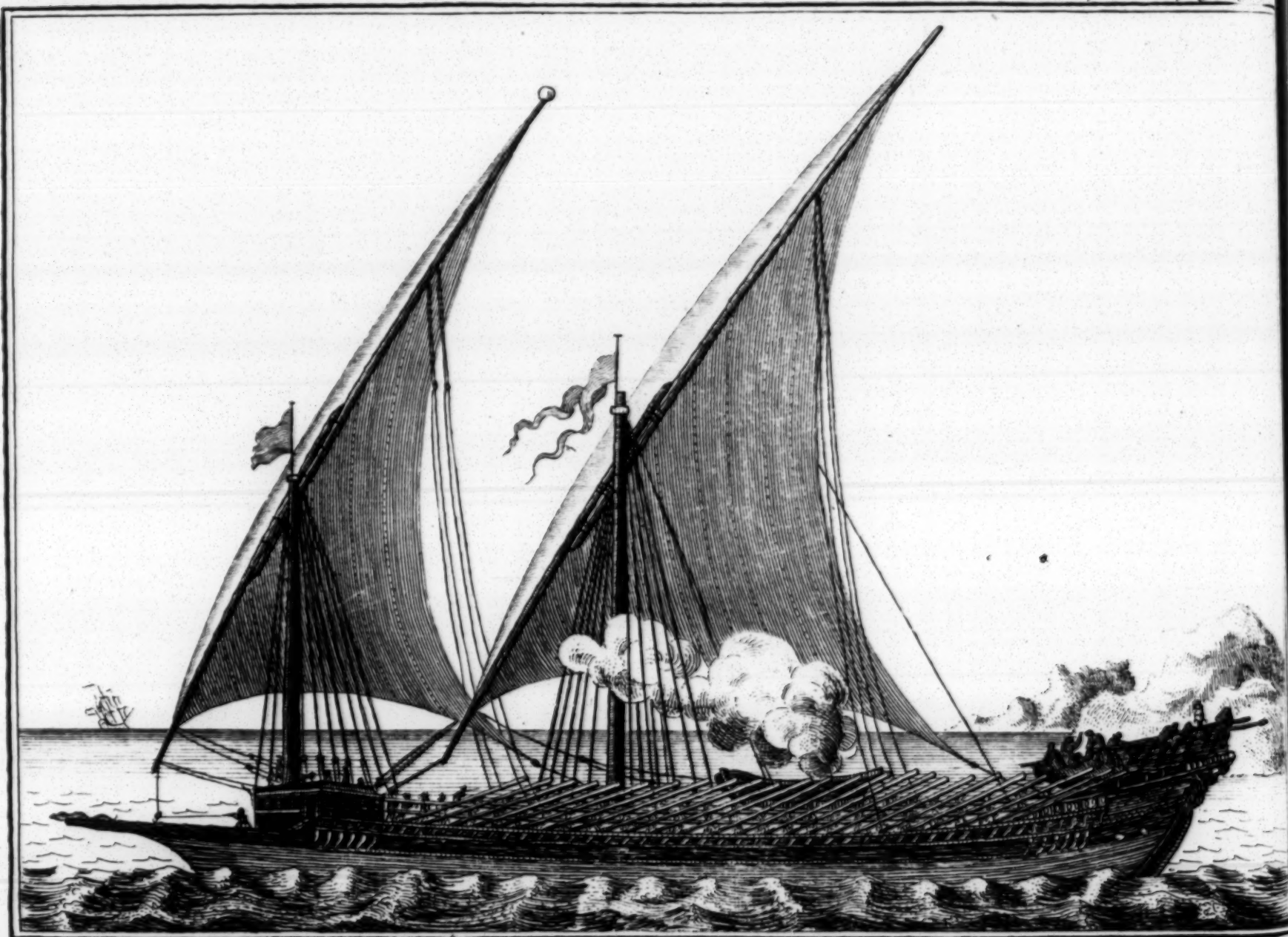
is a very dangerous sort of these Worms, that gnaw their way into the Wood, and feed upon it, taking up their Lodging in it a little below the Surface of the Water, probably to enjoy the Benefit both of the Water and the Air. This Worm having bored for itself a Habitation in the very Heart of the stoutest Planks, glues round its Body a long Pipe, which probably consists of a viscous Substance that perspires through it, and this Case dries and hardens round it. The Worm lengthens this Pipe as it grows by the Addition of new Rings, but leaves it open at the Extremities, whilst the Body of it fills the intermediate Space. The upper End is filled with the Head of the Worm, that next to the Water with two broad Paws, in the Form of Wings, which are joined to the Tail of it. Its Head is armed with two Teeth like Files, with which it rasps the Wood that it feeds upon: The little Aperture below, which is the only Communication that opens outwards, supplies it with Water as Occasion requires, and serves as an Outlet through which to discharge the Wood it has fed upon after Digestion. Thus it lives, and without stirring from its Hole ingenders a Brood of Insects like itself, that would in a little time dig the Ship as full of Holes as a Honey-comb, were they not frequently to besmear it over with Tar and beaten Glafs, when they lie in any Road or Harbour, in order to lacerate the Mouths and Entrails of such young Worms as have not bored their way into the Wood, and to kill the others in their Nests, by shutting them up close Prisoners. They find themselves under a Necessity of repeating this Precaution often; otherwise these indefatigable and undermining Insects would soon punish them for their Negligence,

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Draught of a Galley

Tom. J. Gulp.

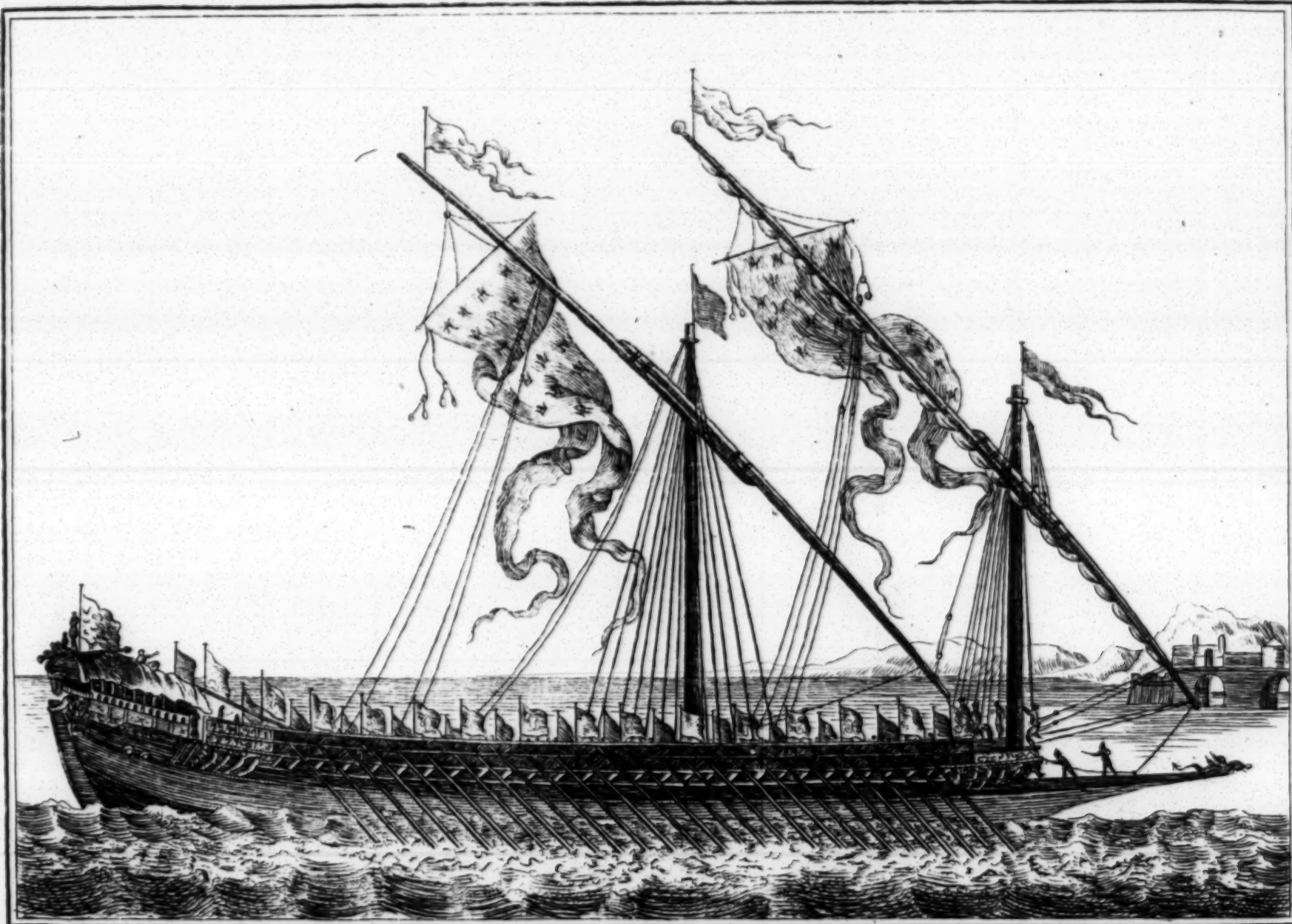


A Galley under Sail

Toms sculp.

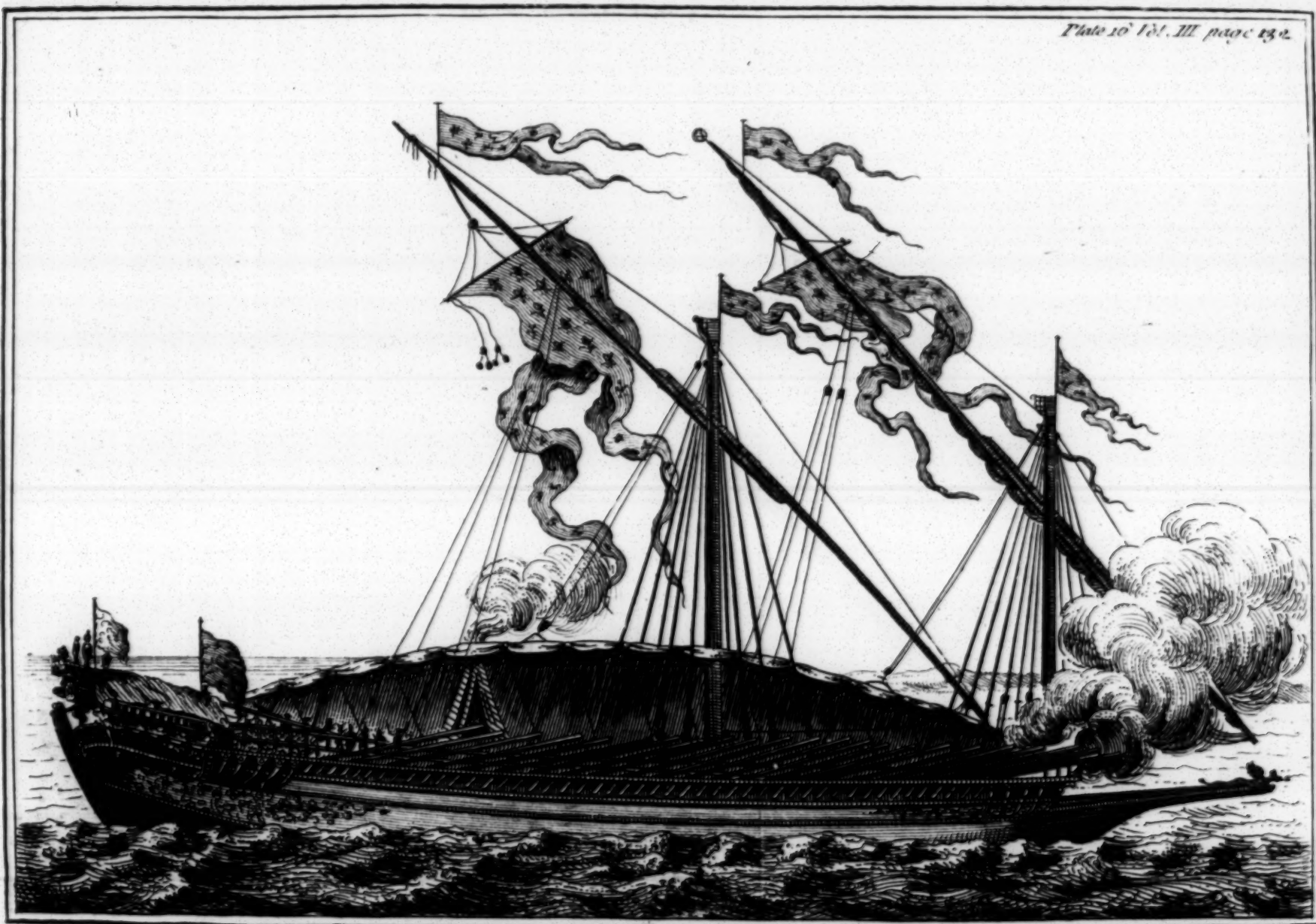


sculp.



A Galley on her Oars.

Towne sculp



A Galley at Anchor.

Town sculp.

gence, seeing the most careful and watchful Mariners have sometimes enough to do to keep themselves clear of them. Thus we see how those formidable floating Castles, that carry whole Armies, and belch out Fire and Smoak on every side, seeming at once both the Glory and Safeguard of Kingdoms, are in Danger of perishing by the Bite of a little insignificant Animal; we see how so mean a Creature as a Worm, in the Hand of God, is a sufficient Instrument to let Men see the Weakness of all their boasted Strength. These Worms have more than once alarmed one of the most flourishing * Republicks in Europe with terrible Apprehensions.

Let us now cast an Eye towards the Extremity of the Port, where they are employed in lading a Vessel. You see the Wharf all covered with Merchandise, which when packed up with Art and Skill, will all lie in the little Compass of that Vessel.

Cbevalier. Pray, what may be the Burden of a great Ship?

Prior. The Burden of a Ship is reckoned by the Ton; a Ton contains The Burden of a Ship. twenty Quintals, and every Quintal a hundred Pounds Weight, consequently a Ton is the Weight of two thousand Pounds. Ships are of different Shapes and Sizes; some are not above forty or fifty Foot long, fifteen or sixteen broad, and nine or ten Foot deep; others there are near two hundred Foot long, thirty or forty in Breadth, and fifteen or sixteen Foot deep. The smaller Vessels, besides five or six Sailors, Rigging, Provision and Guns, will carry about fifty or sixty Ton of Goods. Those of a middle Size, will carry two or three hundred Ton; and the largest of all, five hundred or more, that is to say, five hundred times two thousand or one million of Pounds.

Cbevalier. By the Side of that Ship that they are lading, there lies one built in a A Galley. quite different Form from the rest. The smaller Vessels, I observe, have but one Mast, and one Yard-Arm; the larger Ships have several Masts, and are

* The States of Holland, who were put in Fear not long ago of having their Dikes destroyed by these Worms.

high-built; but this here is quite flat, and has, besides its Masts and Sails, something like two large Wings, the Use of which I cannot apprehend.

Prior. The Vessel you see there is a Galley, which goes either with Sails or Oars: Those that you call Wings are nothing more than two Rows of long flat Pieces of Wood, which the Galley-Slaves keep suspended in the Air when the Vessel sails, and which they let down into the Water, and move too and fro in the Water in Concert, when they are becalmed, or have the Wind against them. The Handle of the Oar is round, and comes within the Galley; the other End, which is in the Water, is flat and broad. The Rowers take hold of the Handle, and pulling it towards them with all their Might, give the broad End of the Oar a contrary Motion; which meeting with a Resistance from the Water, becomes, as it were, a Lever pushing on the Vessel in a contrary Direction. These Gallies are only used in the *Mediterranean*, and seldom seen in any other of our Sea-Ports.

Let us now proceed to take a cursory View of the other Pictures. The next that you see there is a Representation of the principal Accidents that Mariners are subject to.

Picture V. Calamities incident to Mariners.

Of the four Ships that you behold upon this Sea, two of them are described as engaged in a Sea-Fight; one is a Christian Vessel, defending itself against a *Sallee* Privateer; but the Smoak of their Cannon hinders us from having a distinct Sight of them; besides, the Painter has prudently removed an Object so shocking and disgraceful to human Nature, to the most distant Point of View. On the other hand, he has placed directly before us two Ships, shewing a quite contrary Disposition to each other: The one, as you may know by her Colours, is an *English* Ship, that has been driven out to Sea by adverse Winds, and has consumed all its Provision; you see all the Crew drooping, and just ready to die with Hunger; but at the Sight of two *French* Ships coming up to them, to which they made a Signal of Distress by firing a Gun, you see Despair vanishing from every Face, and Hope and Joy brightening up in each Man's Countenance. The *Frenchman*, having computed what Provision he could spare,

spare, and what was necessary for his Voyage, freely consents to relieve their Distress, and to rescue them from the Jaws of Famine. See with what Readiness and Vivacity the charitable *Frenchmen* run from Deck to Deck with necessary Refreshments; but, above all, take Notice with what Tendernefs and Compassion they administer Comfort and Consolation to those that are more than ordinary sick and weak, whilst they, fixing their Eyes upon their generous Benefactors, seem wholly taken up with expressing the Sense of their Obligation, by all possible Demonstrations of Gratitude.

Had not the Painter been confined to too narrow a Compass, and obliged to proportion the Number of Pictures to the Extent of the Gallery, he would have added to these several other Disasters that Mariners are exposed to on the Sea, as running a-ground on the Shallows, striking on Rocks or Sands, that of a Leak, when the Ship takes in more Water than her Pumps can carry off, or when a Ship is by any Accident set on Fire.

Having thus touched on the principal Mischances that are incident to Sailors, let us pass on to those Pictures that were designed to give us a Notion of Commerce, by a Representation of some of those Parts of the World that are most frequented by Merchants, and where the greatest Traffick is carried on.

In the first Place you are presented with the grand Fair of *Porto-Bello*, situated on the Shore of the *Isthmus*, that unites *North* and *South-America*. Upon the Arrival of the Merchant-Ships, and the Galeons that convoy them, this little Town is for six Weeks the greatest Mart in the World, by reason of the vast Concourse of Traders from all the neighbouring Nations, that come thither to barter their Commodities for those of the *European* Merchants.

Picture VI. The Galeons, and Fair of *Porto-Bello*.

At the Bottom of the Picture you may observe a long File of two thousand Mules, that have brought across an *Isthmus* seventeen Leagues broad, to *Porto-Bello*, all the rich Merchandise imported from *Panama* to *Chili*, *Peru* and *Mexico*. You see the Port and all the Wharfs crowded with Chests, Casks and Bales of Skins, Tobacco, Sugar, Indigo, Cochineal, and numberless other Drugs:

Up

Up and down lie Wedges of Gold and Bars of Silver, waiting the coming of the proper Officer, that is appointed to weigh them, as little regarded, and in as great Disorder, as Pigs of Lead in our common Warehouses.

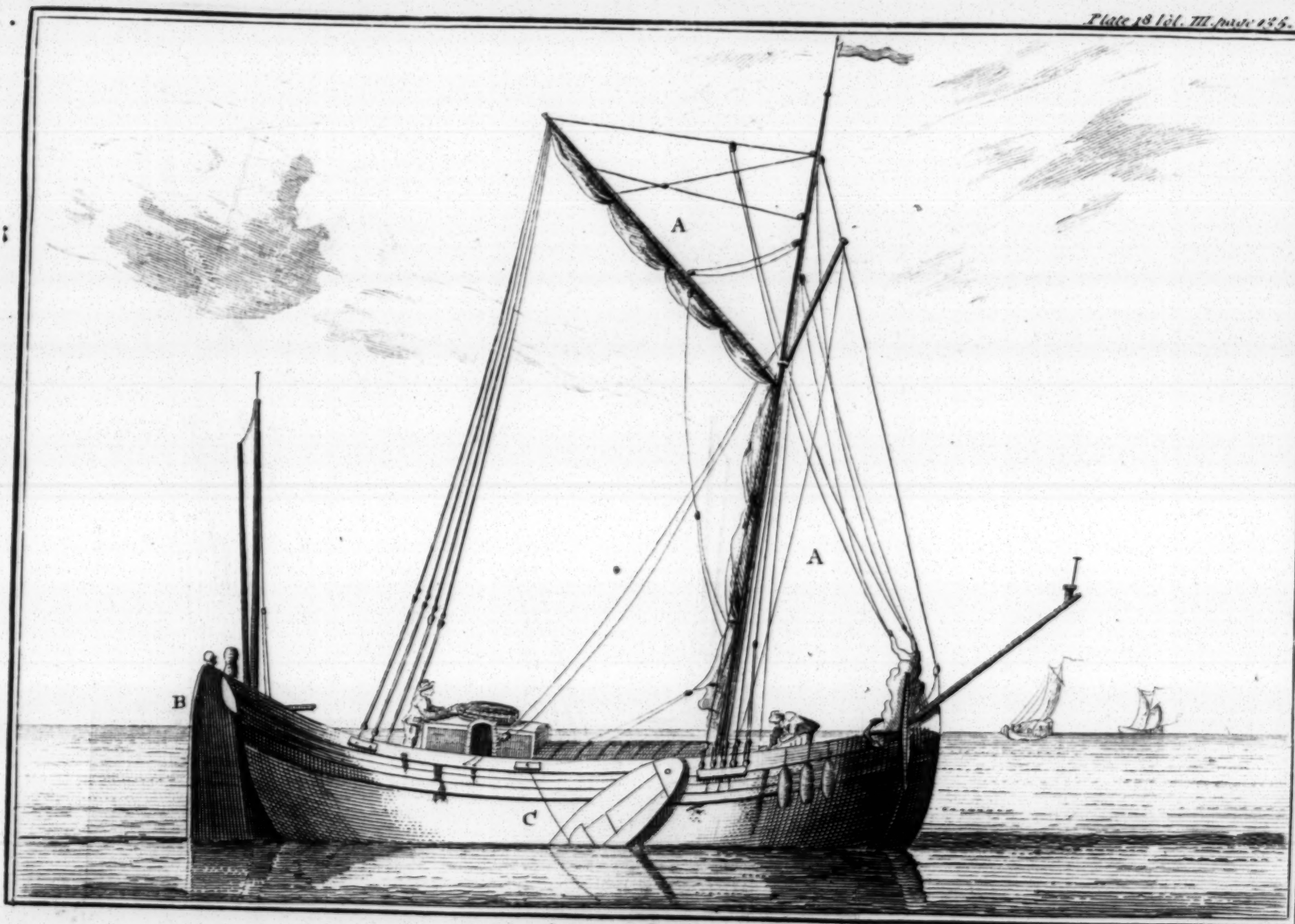
The Galeons, after having taken in their Cargo, get ready to join another Fleet at the *Havannah*, which comes laden with as great Quantities of Goods from *Vera Cruz*: Then the two Fleets sail together back to *Cadiz*, fraught with those immense Treasures which the *Spaniards* afterwards divide out, with strict Honour and Justice, to the other *European* Nations, who before stocked them with Linens, Hats, Stuffs, and such other Commodities as they trade with to their *American* Colonies.

The next Picture is a Representation of
 Picture VII. The that strange sort of Commerce that the
 Traffick of the Negroes on the western Coasts of *Africa*
 Negroes. carry on with the *Europeans*, selling for
 Slaves, not only their Prisoners of War,
 but even their own Children.

The Prospect in this Picture is terminated by a View of the Coast of *Angola*, where, though they barter Gold-Dust, Gums, Elephants Teeth, Ostrich Feathers, *Guinea* Hens, Leopards Skins, and several sorts of Hides in Exchange for Iron Ware, Glass, Toys, and other *European* Trinkets of little Value; yet the chief Commodity of the Place are Negroes, which they sell to the Merchants that come here to buy them for the *American* Plantations, where they employ them in Husbandry. Observe in that Groupe of Figures a Mother, in a very unconcerned manner, delivering up her Daughter to a Stranger for a few white Shells, called *Cowries*, which is the current Money of that Country, and of which the Negro-Women make themselves Collars and Bracelets to give a more sable Hue to their sooty Complexions. Near this unnatural Mother are two Lads selling their own Father, whom they had surprised, and bound with Cords: The Price they receive for him, is some Hedging Bills, and a few Bottles of Brandy.

Chevalier. This is a most shocking Spectacle; though, to confess the Truth, I must needs own, that my Indignation is not less raised at the Inhumanity of the *European* Purchasers,





A little Vessel

Tom's sculp.

Purchasers, than at the unnatural Barbarity of the Sellers.

Prior. Let us pass on then to a more agreeable Sight. This is the Market of *Surat*, the greatest *Emporium* of the *Mogul*, and of almost all *India* besides, frequented by the greatest Concourse of People of different Nations, and where is carried on the greatest Trade for Jewels, Silks, Cotton, Tapestry, rich Stuffs, and Spices.

Picture VIII.
The Market of
Surat.

Chevalier. This Picture does indeed display Magnificence and Opulence in great Variety; but here is another that wears a quite different Aspect. Pray who are these People that seem clad like Bears? Their Figure and their Mountains covered with Snow together, make me almost shudder with Cold.

Picture IX. The
Greenland Trade.

Prior. Their Manner of Trading is not less fullen, than their Figure is frightful. These are *Greenlanders* exchanging some Sea-Dog and Sea-Calf-Skins, the Teeth of certain Fishes highly valued for their exceeding Whiteness, and Whale-Grease and Oil, for Commodities which some *Danish* Fishermen have brought to barter with them. And all this Negotiation is transacted without the Use of Speech. The *Greenlanders* lay together in a Heap what they have a mind to sell, and the *Danes* make another of the Goods they are disposed to exchange for it: If the former do not think the Parcel of the latter equivalent to theirs, they take away Part from their own Heap; thus when by diminishing or augmenting their Heap on either side, they have so far adjusted this Agreement, that both Parties are content, they then carry off their Bargains without speaking a Word; the *Dane* retires to his Ship, and the *Greenlander* to his Den.

All these Pieces that are Representations of Commerce are bounded by the Port of *Amsterdam*, which one may call the Rendezvous of all Nations, and in some Sense the Centre of the Commerce of all Parts of the World.

Picture X. The
Port of *Amsterdam*.

Chevalier. Amidst this vast, though agreeable Variety of Objects, nothing pleases me so much as the different Airs and Habits of the different Nations.

Prior.

Prior. The Painter has shewn a great deal of Skill in matching them ; here he has given us the opposite Dresses of the *Spaniard* and the *Armenian* ; there you see the Hat and the Turbant together ; in another Place he has set off the graceful Mien and Appearance of a young Nobleman upon his Travels, by shewing him as talking to a clownish Sailor. You may distinguish the *Chinese* by his tawny Complexion, the *Arabian* by his Wainscot Face, and the *African* by his flat Nose ; in a word, you may know, by their different Airs, Dresses, and Complexions, all the People of the World that trade in this great Town.

Chevalier. I have heard it asserted, that there go out from this Port every Year, about three thousand Vessels besides Fishing-Barks.

Prior. And yet for all this, the seven little Provinces, of which this is the Capital, are not, all taken together, bigger than the Province of *Normandy*, and the Land not one fourth Part so good ; but notwithstanding, Navigation and Industry have rendered this Republick as considerable for Trade, as any Empire or Kingdom in *Europe*.

Chevalier. I always heretofore looked upon the Sea, as a Boundary appointed by God for the Division and Separation of Nations ; but the single Instance of *Holland* now convinces me, that it was designed as an Expedient to unite and bring them together, and that God has hereby been pleased to make every particular Country amends for what it does not produce, by contriving so easy a way of conveying their respective Commodities to each other, which, without such a Conveyance, would have been entirely impracticable.

What then could *Horace* * mean by those Reflections which he has cast upon the Man that first invented the Art of Navigation ? The Poet looked upon these Tracts of Water that divide one Country from another, as so many

* Illi Robur & Æs triplex
Circæ Pectus erat, qui fragilem truci
Commisit Pelago Ratem
Primus, &c.

Trenches cut out on purpose by the Hand of God *, to prevent any Communication betwixt them, and thought it a piece of Impiety for him to presume to pass over these Bounds.

Prior. *Horace* did not know that it was God himself who first taught Mankind the Art of Navigation: Besides, we are to consider, that when he wrote this Ode, he was in a peevish Humour, and was just come from attending his Friend *Virgil* to the Port, who was going to embark for *Greece*; and after a thousand tender Wishes, and parting Sighs, he gave Vent to his Chagrin, by abusing the Author of that Invention, by which he was now separated from so excellent a Friend. One is sometimes out of Humour upon more frivolous Occasions, and when we are in a fretful Mood, you know we are apt to attend to the Dictates of Passion, more than to those of Reason.

But after having taken a Survey of the external Parts of the Sea, it is time to descend a little into the Bosom of the Deep, and to take a View of its Inhabitants. We did some time ago entertain ourselves with the Contemplation of some of those wonderful Methods, by which the Providence of God does preserve in Places, to all Appearance, quite barren, an inconceivable Number of Animals, and useful Productions: Let us now make use of the present Opportunity, which these Pictures afford us, in admiring the same wonderful Designs of that Providence in the Formation of some of the most remarkable Animals that have their Habitation in the Sea. The first of these Pieces is a Representation of the fa-

mous *Greenland* Fishery. The Harpoon or sort of Javelin which you see the Fisherman in the Middle going to throw, was by the Painter very judiciously marked out into six equal Spaces, which are to represent so many Feet; the last of these Divisions is again subdivided into twelve equal Spaces or Inches, to the end that by the Assistance of this Scale we may be able to take the

Picture XI.
Fishes of the
larger Size.

* Nequicquam Deus abscidit
Prudens Oceano dissociabili
Terras, si tamen impiae
Non tangenda Rates transiliunt Vada.

Carm. Lib. I. Ode, Sic te Diva, &c.

exact

exact Length of the Fishes, and to know the Proportion they bear to one another.

The largest of all is the Whale, which instead of Teeth has a sort of Tusshes growing within his Jaws, sometimes fifteen Foot long, coming from the Roof of the Mouth, and ending in a sort of Fringe resembling the Bristles of a Hog. I need not tell you what Use * is made of these Excrescences, which are both so limber and so strong. Those other great Fishes that you see there, as the Ork, the Grampus or Whirl-Pool, the Scolopender, the Monoceros, and perhaps several more besides these, are all of the cetaceous Kind, and are included under the common Name of Whale, and are equally reputed for their Oil. Their Mouths are armed with sharp Teeth, and they have on their Heads one or two Pipes, through which they spout out the Water they take in. This Office in other Fishes is performed by that kind of Lungs which in *French* we call, though improperly, *Les Oues* †. Divers of them discharge the Water they swallow in eating, through several Holes ranged on each Side, a little below the Head; as you may remark in all the Sea-Dogs placed here in a Row one after another; you may know them by the Roughness of their Skins, and their Mouths being more inclined downwards.

The Balance-Fish. *Zygena*. Of these the Balance-Fish has the oddest Shape. In some Countries they eat the Flesh of all these Fishes, as well as that of the Dolphin and Porpoise or Sea-Hog, though it is very oily and rank. The Dolphin is distinguished by that hollow or sinking in betwixt the Snout and the Top of his Head; the Porpoise has a rounder Head. These are seldom above

The Whale.
Balæna,
Cetus, *Cetum*.

The Ork.
Orca.

The Whirl-pool
or Grampus.
Physeter.

The Scolopender.
Scolopendra.

Unicorn-Whale
or *Monoceros*.

The Porpoise.
Porcus marinus
or *Phocæna*.

Dolphin.
Delphinus.

* Of these is made what we call *Whale bone*.

† This Word *Oues* (in English, *Gills*) comes from the Verb *Ouir* to bear, and implies that these are the Organs of bearing in Fishes; though falsely. See p. 64.

four or five Feet long. The Fat and Flesh of the Sea-Calf are still much more valued: You see it yonder running on the Rocks upon the Coast; as is also that of the Sea-Cow, called in *French* *Lamentin*, by reason of its Bellowing.

The Seal or
Sea-Calf.
Pbocæ.

Chevalier. It seems then that these are amphibious Creatures. The Sea-Cow has two Feet formed in the Shape of Hands, and the Sea-Calf has four, the Extremities of which are like Fins; I suppose, to enable it to go backwards and forwards on the Land as well as in the Water: But pray, what do you call that Fish that suspends, or rather hooks itself to the Rock with two large Teeth, which bend back towards its Breast in the Form of Tenter-hooks?

The Sea-Cow,
or *Lamentin*.

Prior. This is a sort of Sea-Calf, on which Nature has bestowed the Instruments to enable it to climb up upon floating Flakes of Ice, or upon the Land, it being necessitated every now and then, as well as Otters, Castors, Tortoises, and all other amphibious Animals, to quit the Water, and seek a Retreat in the open Air to enjoy the Benefit of a freer Respiration. This is the Fish that is called a Walrus, the Teeth of which are more valued than Ivory, by reason of their extreme Whiteness. I remember that I formerly * spoke of the Walrus and Narval as one Fish †; but the Narval || or Sea-Unicorn is a little Whale armed with one Horn five or six Foot, sometimes several Yards, in Length. You are sufficiently acquainted with this Creature, and need not be told of what Advantage this Weapon is to it in its Engagements with Whales of the most enormous Size.

The Walrus.

The Narval.

Chevalier. Here are two other Fishes, methinks, still more terrible than the former. I remember to have seen

* *Vol. I. Part 2.*

† Relying on the Testimony of Mr. *Savery*, *Dict. de Comm.*

|| *Vid. Museum Wormian. p. 282. Johnston. Tab. 44. p. 227.*

The Sword-Fish.
Xiphias.

The Saw-Fish.
Pristes, Serra.
See the Frontisp.
of Vol. I.

The Shark.
Canis Carcharias, Lupus, Galerius Canis.

The Sea-Bat.
Hirundo maritima.

of them before in the Cabinets of the Curious. One is called the Sword-Fish, from having its upper Jaw lengthened into a long sharp Sword, with which it sometimes pierces the Ships; and, though it is never above fifteen or sixteen Foot long, yet thus armed it dares give Battle to the Whale itself. The other is called the Saw-Fish, from carrying in its upper Jaw a long Bone like a Blade, set on each Side, with a Row of sharp Teeth, with which it cuts the Fishes it pursues, or those that pursue it.

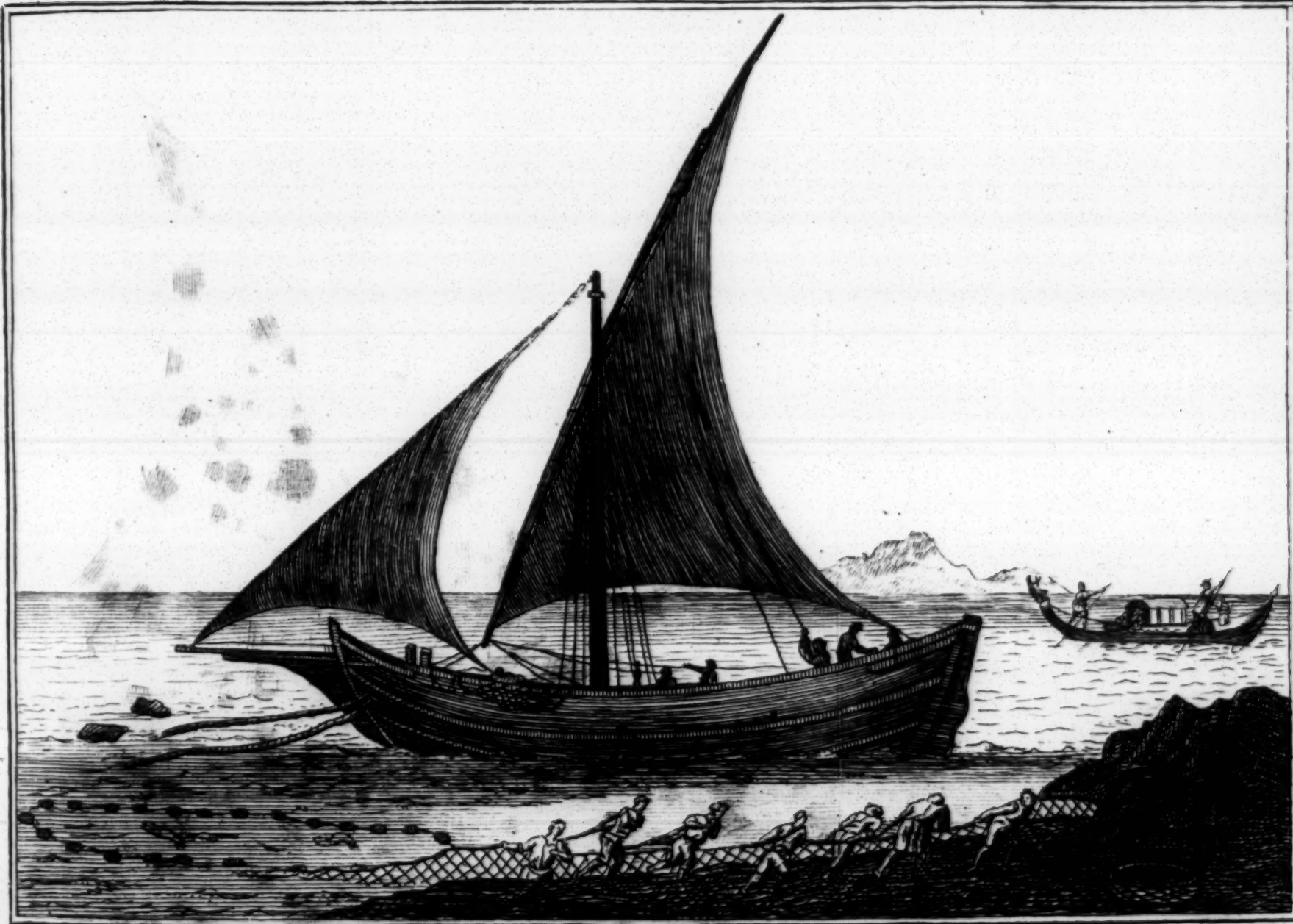
But I don't know the Name of that Fish, which seems so remarkable for its Length, and the Fury with which it gnaws the End of the Bark that is come to attack it.

Prior. It is the Shark, the most terrible of all the Sea-Dogs. It has in each Jaw five, and sometimes six Rows of triangular, indented, and very sharp Teeth. It has a very long Gullet, and in the Belly of it are oftentimes found the Bodies of Men half-eaten, sometimes whole and entire. It is covered with a rough, but close-grain'd Skin, with which the Trunk and Case-Makers cover a great many sorts of Boxes and Sheaths. They make the same Use of the Skins of some other Sea-Dogs, and also of a certain sort of Rays or Thornbacks.

Chevalier. I always looked upon the Accounts that are given us of flying Fishes as mere Fables; but I see several here that spring up into the Air, and seem to expand a couple of Wings.

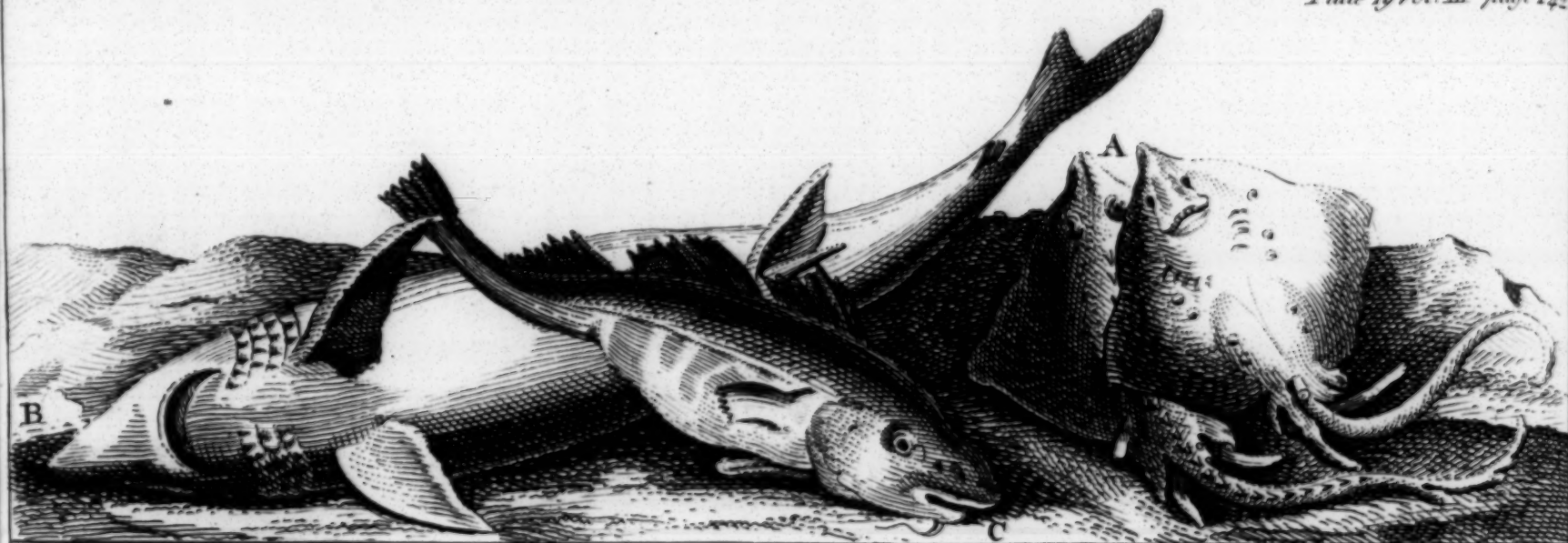
Prior. There are indeed several, which, when pursued by the larger Fishes, make their Escape into the Air by the Assistance of their long Fins, with which they wing their way till they become dry, when not being able to support them any longer, they let them drop again into the Sea. There are also some very large Fishes, that being stung by certain Sea-Insects, dart out of the Water, and sometimes chance to fall into the Fishing-Boats.

Next



A Fishing Bark

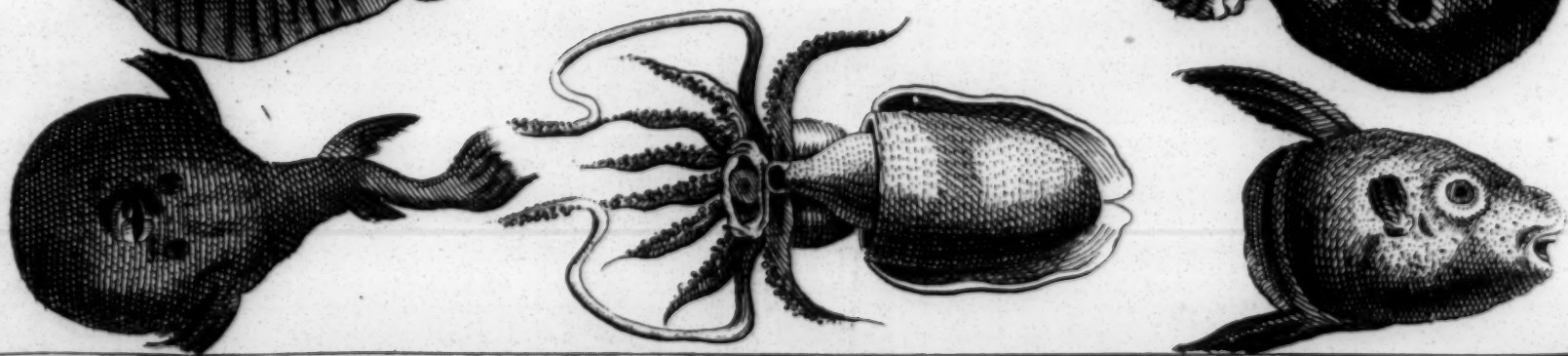
Wm. Sculp.



E



F



H
Thornbacks &c.

Done sculp

Next to the Fishery of these gigantick fishes, and of several others that vary according to the different Seas they are in, you are here entertained with a very particular and agreeable Representation of every thing relating to the Manner of fishing for the Tunny, the Pilchard, the Whiting, the Herring, the Mackrel, the Cod, and the Stock-Fish. The Melvel, which is a sort of little Cod, is called in *Dutch* Stock-Fish, or Stick-Fish, because that after it has been dried, it must be beaten in order to make it tender and eatable. The Right of catching these Fish brings in to those People to whom it does belong a greater and more certain Revenue than the Mines of *Peru*; for these may be exhausted, but the Banks of *Newfoundland* alone do and will always continue to bring in to the Proprietors of that Fishery a Revenue of several Millions *per*

Annum. Several Nations in the *North*, where the quick Return of the Frosts sometimes nips their Fruits before they come to Maturity, find a sure Refuge in those Shoals of small Cod, Whittings and other Fish that frequent their Coasts. These they dry and keep by them a whole Year; and sometimes they pulverize them, and make a sort of Bread of them, thereby repairing the Damage they sustain by the Loss of their Harvest.

In several Parts of the Torrid Zone, the People who live on the sandy Coasts, (being destitute of Wood, and all kinds of Vegetables) build their Houses with the Bones of large Fishes; the biggest they use by way of Beams and Joists, with the lesser Bones they build their Walls and Partitions; of the Flesh they make Bread, and sundry sorts of Dishes. So bountiful has Nature been to Man, that where-ever she has denied him one Convenience, she is sure to make him amends by the Gift of another!

Here you see a Picture of a different Kind, but which comes in very *à propos* after Fishing-Pieces. It represent a large

Picture XII.
Fishes of Passage.

The Tunny.
Tbunnus.

The Whiting.
Alburnus.

The Herring.
Halec.

The Mackrel.
Scombrus.

The Cod.
Asellus.

The Stock-Fish.
Sa'pa.

The Ichthyophagi
or Fish-Eaters.

Picture XIII.

Kitchen

Kitchen furnished with a great Variety of the most delicate Fishes for a sumptuous Entertainment; and that all Palates might be pleased, they have provided likewise some of the common Sort. The Fish that first strikes the Eye by reason of the Largeness of its Size, and

The Sturgeon.
Sturio or *Acipenser*.

The Turbut.
Rombus.

The Plaife.
Passer levis.

The Bret-Fish.
Passer squamosus.

The Sole.
Lingulaca.

which will be the Flower of the Feast, is the Sturgeon; next to which is a fine Turbut, a Fish of so exquisite a Taste, that it is called the Pheasant of the Water. This is succeeded by some other flat Fish resembling the Figure of a Lozenge, some of which have no Scales, as Flounders, that are dappled with reddish Spots, and the Plaife, which is generally bigger; others are covered with little Scales, as the Bret-Fish, the Flez *, and the Helbut †. These are followed by several Pairs of Soles, which, for the Variety of their Kinds, and their delicious Taste, may take Place of any Fish that swims.

All those that we have named after the Turbut are white on the under Side, but the upper Side of them is of a darkish grey Colour, the better to resemble the Colour of the Mud in which they conceal themselves. You readily, I don't doubt, perceive the Reason why Nature, which to all other Fishes has given an Eye on each Side, has in these placed both the Eyes on one Side.

Chevalier. The Reason is plain; for as they swim but very little, and that always with their white Side downwards, the opposite Side must be the most convenient Situation for both their Eyes.

The Thornback.
Raisa.

Prior. Here are several sorts of Thornbacks, which are all more or less studded with little sharp-pointed Bones. The most esteemed of them are those that have sharp Prickles sticking up in the middle of their Backs on a sort of very hard Buttons; whence they are properly termed Thornbacks. Hard

* *Flejus Bellonii*. Vid. *Raii Synop. Method. Piscium*, p. 32.

† Vid. *Gesner. de Aquatilib.* p. 666. Edit. *Francos.* 1620.

by these you see a Cramp-Fish, and a Fork-Fish, both which many People mistake for a sort of Thornbacks. The Cramp-Fish is endued with a very remarkable Quality, which is, that it benumbs all on a sudden whatever Fish it attacks, and the Arm of the Fisherman that takes hold of it; by which means it both makes its Escape, and secures its Prey. The Puffin or Fork-Fish is armed with a strong sharp Sting: Both the one and the other of these Fishes are good Eating, notwithstanding the ill Name that the Prejudice of some People has fastened on them.

The Thornback, like the Whale, the Sea-Dog, the Porpoise or Sea-Hog, the Dolphin and some others, is viviparous; that is, does not lay Eggs or Spawn, but brings forth one or two young ones, which the Mother suckles and nurses with great Care.

Next to the different Species of Thornbacks, we are presented with several Kinds of Sea-Eels, the chief of which are the Mourene *, which has but two Holes beneath its Gills; the Lamprey, which has fourteen, as also the River-Lamprey or Lampern; the Sea-Serpent, which has a very rich Taste; the Ophidion or Sea-Eel-Powt; the Conger with its two Fins resembling the Sea-Serpent, and the fresh Water Eel; and the Needle-Fish. Amidst that vast Variety of other Fishes that do more or less partake of the Nature of the Eel, we will content ourselves with taking Notice only of the Quaviver or Sea-Dragon. The Flesh of this Animal is much ad-

The Cramp-Fish.

Torpedo.

The Puffin or Fork-Fish.

Pastinaca.

Vid. *L'Emeri.*

The Mourene.
Muræna.

The Lamprey.
Lampetra.

The Sea-Serpent.
Serpens marinus.

The Sea-Eel-Powt.
Ophidion.

The Conger.
Congrus.

* Mr. Ray, in the critical Remarks of his Nomenclator, says, that the Lamprey has been by Mistake called *Muræna*; whereas the *Muræna* is a quite different Fish, common in the Mediterranean Sea, and called at this Day Mourene. Yet Rondeletius (adds Mr. Ray) will have it to be the *Muræna fluviatilis* of Athenæus; however it must by no means be called simply *Muræna* without the distinguishing Epithet of *Fluviatilis*.

mired.

The Needle-
Fish.
Acus.

mired. It has upon its Back pointed Bones, the Prick of which is very dangerous, even after it is dead, and sometimes severely punishes the heedless Cook for his Carelessness; but after it has been a little while on the Fire, it loses that Venom which makes the Wound to fester, and so hard to heal.

The Quaviver,
or Sea-Dragon.
Draco marinus.

Chevalier. Sure the Design of this Feast was to entertain the Guests with the odd Shapes of the Fishes, as well as the great Number of Dishes; for here are some of the strangest made Creatures that ever I beheld.

The Sun-Fish.
*Orbis, Luda,
Piscis.
Raii Synop.
Method.
Piscium, p. 51.*

Prior. This here, which is formed like a Globe, its Head and Body being all but one Lump of Flesh, is called the Sun-Fish. There are several Sorts of them, one of which has no Tail, and would be one entire round Mass but for two little Fins which serve it by way of

Oars. The Painter could not have given a better Proof of his Judgment in setting off the vast Variety of these Creatures to the best Advantage, than by placing next to the Eels these lumpish, clumsy Fishes, and then the

The Cuttle-
Fish.
Sepia.

Cuttle-Fish, the Calamary and the Pourcontrol, which are divided into so many Parts or Members. The Cuttle-Fish and the Calamary have, besides several Claws, two long Trunks which serve them to lay hold of their Prey at a Distance.

The Calamary.
Loligo.

The Pourcontrol or Polypus has, besides its eight Claws, an Excrescence that rises up on its Back in the Form of a Pipe, which he inclines to the right, or left Side, to steer him as he swims along.

The Pourcon-
trol.
Polypus.

The Cuttle-Fish, the Calamary, and the Polypus, have all three a Magazine of Ink, or Bladder full of a black Liquor, which proves of great Service to them when in Danger of being caught; for either through Fear or natural Instinct, they shed this black Liquor, and discolour the Water all around them; so that whilst the Enemy is groping in the Dark for his Prey, and is at a Loss where

where to seek for it, it gives him the slip, and makes its Escape.

Had the Painter, instead of representing a costly Entertainment, display'd a Fish-Market with the greatest Part of the Fishes that are there expos'd to Sale, he would not have pass'd over the Scare; which, as they tell us, (tho' perhaps without Foundation) is wont to come ashore, and browse upon the Grass that grows on the Sea-Coast, and there chew the Cud at its Leisure: Nor would he have forgot the Mullet, which is very like the River-Chub, if it is not of the same Species, tho' it thrives better in the Sea, and comes to be of a larger Size. The Spawn of this Fish when dried is much set by in some Countries; it is the same with Botargo, and is eaten with Oil and Juice of Lemon. To the Number of choice Fishes we might also add the Surmullet, which seldom grows to be heavier than two Pounds; the best sort of these are those that have two Whiskers: the Gilt-Head or Sea-Bream, of which there are several Kinds; it is reckoned a choice Fish, and is about a Foot and half long: the Piper, the Ox-Eye, the Pilchard, or little Herring, and all the different sorts of Anchovies, which (when they have taken off their Heads, and gutted them) they put in Pickle.

There are besides these already mentioned, a vast Multitude of Fishes that differ both in Shape and Taste; some of which make their constant Abode on our Coasts, some make us a Visit at certain Seasons of the Year, and others come as Chance directs them; for God's Gifts are without Number in the Sea as well as on the Land.

Whatever Pains both ancient and modern Authors *

* Aristotle, Pliny, Ælian, Oppian, Rondelet, Gesner, Billon, Aldrovandus, Jonston, Salvian, Willughby, Ruiseb, Scheuchzer, Bonanni, Lemmeri, Vallisneri.

The Scare.
Scarus or
Sargus.

The Mullet.
Mugil.

Botargo.

The Surmullet.
Mullus.

The Gilt-head.
Aurata.

The Piper.
Lyra.
Gesner, de
Aquat. 516.

The Ox-Eye.
Boops.

The Pilchard,
Maena, Hale-
cula.

The Anchovy.
Apua.

have taken to distinguish the several Genus's and Species of Fishes, by particular Marks and Descriptions; yet scarce a Day passes that does not convince us, how scanty and defective all their Systems of this kind are, by discovering to our Fishermen some new Sorts before unknown, and which puzzle our most skilful Naturalists, who are often at a Loss under what Class to range them, or what Name to give them.

Chevalier. This is however a very agreeable kind of Perplexity, and an Argument that we are so exceeding rich, as not to know an End of our Store.

Prior. Let us pass on next to another Profusion of Riches that the Sea pours in upon us, every time it increases and floods our Coasts, in those vast Quantities of Lobsters, Oysters, and all sorts of Shell-Fish, that it brings up along with it; whence, after having fattened them, either with its own Substance, or such nutritive Particles of Earth and Air as are contained in it, it retires by a gentle Decrease, and gives Man Access to this Provision of Dainties, inviting him to come and gather its Favours, which it has so liberally scattered upon the Shores, or left upon the Rocks. Thus does the Sea, like the Finger of *Midas*, make rich where-ever it touches, producing on the barren Shores a Crop of greater Value to the Owner, than the most fertile Pastures or arable Land.

Picture XIV.
Shell-Fish.

Is it possible, my dear *Chevalier*, to help being charmed with that surprizing Variety of Figures, and that Richness of Colours displayed in this Picture of Shell-Fish? The Painter has not attempted here to give us all the Sea-Reptiles, for they are without Number*; nor yet every individual Species that belongs to any one Genus; for they vary in so many Particulars of Shape and Colour, that the Task would be impossible; but he has been at the Pains to collect all the principal Kinds under which, as so many Classes, may be ranged those Shell-Fish that we are most acquainted with. I don't doubt but the Particulars exhibited in this Piece, are pretty familiar to

* Illic Reptilia quorum non est Numerus, *Pf.* 103.

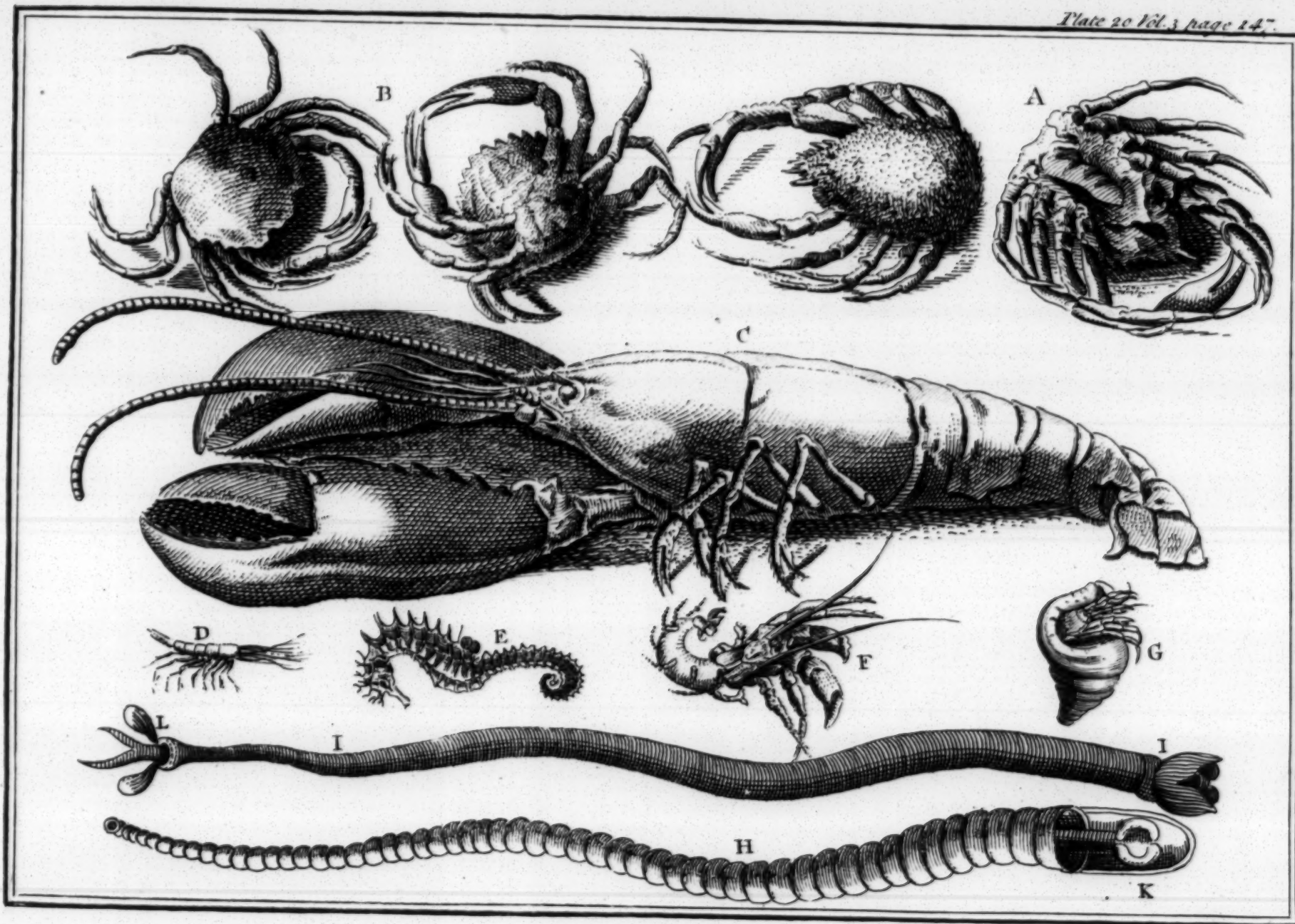
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Crabs

Wms sculp.

you, seeing they are taken from that valuable Collection of Shells that you have so often surveyed.

Chevalier. I trace the Originals in the Copies, with a great deal of Pleasure. There is the Lobster, the Prawn, the Shrimp, the Sea-spider, and several sorts of Crabs; but here is one I don't remember, that which thrusts its Claw out of a very beautiful Shell, in which it lies intrenched.

Prior. This is a very particular kind of Crab, which, though Nature * has provided it with a Shell, and given it Claws to defend and subsist itself in an honest way, yet always lives in a House not its own, and owes its Security to the Labour of another; for it is the Way of this Fish to take Possession of the first Shell it finds empty. Sometimes several Antagonists will contend for the same Habitation, in which Case, he that has the strongest Pincers carries the Day. Here he takes up his Lodging for some time, and when he is grown too big for his House, he quits it, and goes from Shell to Shell till he has found one of a convenient Size, where he stays till he is tired of it, or grown too big for it, and then he removes again. This is the Account that Naturalists give us of this Fish, though there is great Reason to suspect that the Character they give of it, as a lazy Animal, that lives by the Benefit of another's Labour, is founded on a Mistake; for Nature knows no such Principle as Idleness, nor ever acts without Reason or wise Design. The Truth of the Matter is this: The Body of that Fish, which is called in *French*, *le pauvre Homme*, or *L'Hermite*, is flabby, and covered with a thin Shell, insufficient for its Security, which obliges it to seek a Shelter in some one of those empty Shells, which are of no Use but to such a Tenant. This Precaution of the Hermit is not unlike that of the little Crab, which being sensible of the Weakness of his Shell, begs House-room of

Fishes of the
Lobster Kind.

The Lobster.
Astacus.

The Prawn.
Locusta.

The Shrimp.
Squilla.

Of the Crab-
Kind.

The Crab.
Cancer.

The Soldier-
Crab or Hermit.
Cancellus.

* Qui Crustâ testus, Chelas habens, quæ ad Viam tuendam satis esse possent, alienas Domos quærat, *Æc. Rondelet. de Piscibus, Lib. 17. c. 12.*

the Muscle, which, having room to spare, kindly admits his Guest, and they live very neighbourly together.

Chevalier. In the second Rank I see the Painter has given us all the different kinds of Sea-Urchins, some of them covered all over with Prickles, others having only a bare thin Shell. One would

take these for so many Buttons instead of Fishes; for they have nothing of the Shape of an Animal. Pray can one discern in these any of those Members that other Animals make use of in the different Functions of Life?

Prior. The Mouth is placed on the Under-side, and touches the Ground; it is fortified with five Teeth, which meet at their Extremities in a Point, that they may all work together: The Stomach and the Bowels fill the Inside of the Shell, which has several Holes in it to give free Liberty to the Action of those Ligaments that are to move the Prickles, which serve them both for Cloaths and defensive Weapons. The outward Extremity of every Prickle is sharp-pointed, the other End next to the Shell is hollowed by way of Socket, that it may the more easily slide on a little Tubercle which is jointed in it. You see several of these Tubercles on most of those Shells that have no Prickles on them; on the upper part of them is the Aperture, where the Intestines end: But what is most remarkable in several Sea-Urchins, is a sort of Bristles which they thrust out, or draw in, at Pleasure; they are like so many small Tubes or Reeds, and with these they separate the Juices which they suck through them from those that are less nutritive or proper for them.

The Painter could not have given a more agreeable Representation of that Contrast, and beautiful Variety that appear in the Works of the Creation, than

The Star Fishes. by placing the Star-Fishes next to the Sea-Urchins; for whereas the latter are almost round, the former stretch out five long Arms or Claws, making five Angles, and ending in so many Points; some of them have more than five, which branch out in a great Number of little Divisions. The Star-Fish moves in all Directions indifferently, sometimes creeping, sometimes swimming; it has several little Trunks of a fleshy Substance, that it darts into the Mud, through which it sucks

its Food; and besides these Conveniencies, it has moreover, towards the Centre of its Body, a Mouth armed with Teeth. As these Creatures do not enjoy the Benefit of Sight, for the discerning their Prey in common with other Animals, Nature has therefore provided them with more Instruments for feeling, sucking, and devouring their Provision; for when they have not an Opportunity of exercising their Grinders, they can go to work with their Trunks in the Mud and among the Weeds, and by that means pick up a tolerable Meal. It has not yet been discovered how the Office of Digestion is performed in the Star-Fish, or how it voids its Excrements, unless it be under a sort of little round Stone which is found upon its Back, and seems fastened to it with Ligaments.

Against the Sea-Stars, or Star-Fishes, which go backwards and forwards, we may set the Sea-Mushrooms, which never quit the Place where they have once fixed their Abode. These little Animals,

The Sea-Mushroom, or Anemone.

of so extraordinary a Nature, are very often found on the Coasts of *Normandy*; some of them are green, some of them are red, and some of other Colours. They are found sticking on the Declivity of Rocks, where they look like Mushrooms, when they are shut and collected within themselves; and like the Anemone, when they open or display all their Trunks. There is no forcing them to open against their Will, though, upon pressing them, they will eject several young ones of different Sizes; which seems to prove, that they are both Male and Female, that they are moreover viviparous, and like the small Worm, that raises the scarlet Pustle in a sort of Holm-Oak, or the Orange-Tree-Bug. You may loosen the Sea-Mushroom from its Hold, carry it away, and keep it in Water, where it will fasten itself again to the first convenient Place it finds. When it has a mind to open, it raises itself, and thrusts out two white Pellicles, striped and bloated like two Bladders, round which appear a vast Variety of Points or Trunks, of different Sizes and Colours, which has given Occasion to some Naturalists to call it the Sea-Anemone. This Opening, not unlike the blowing of a Flower, has inclined others to look upon it as a sort of Plant, or else as partaking both of the ani-

mal and vegetable Nature : But as it is certain that all these little Points or Studs are not Leaves, but a sort of Snouts or Trunks, through which this Animal sucks in its Nourishment, just as the Sea-Urchin and Star-Fish do through their fine Reeds or Prickles, we cannot deny it a Place in the Rank of Animals, especially after so remarkable a Circumstance (confirmed by ocular Testimony) as that of three or four young ones issuing from the Parent, upon squeezing it, after having nursed them till they were in a Condition to subsist of themselves.

From the anatomical Description I have given you of these Sea-Animals, however short and imperfect, you may at least discern a Specimen of that inexpressible Contrivance that appears in the Works of the Creation, and of those various Methods which God has employed, for the Support of different Animals. If you please, we will now pass on to the next.

Fishes having but one Shell.

The Sailor.
Nautilus.

Chevalier. In the fourth and fifth Ranks, I observe, are those Shells that consist but of one entire Piece, among which, in my Mind, the Sailor claims the first Place. I am always delighted with the Figure of that little natural Boat, the Stern of which rises so gracefully in the Water; which is so firm, and at the same time so light, and beautified with such strong and lively Colours.

Prior. You very properly call it a Boat, since the little Fish that inhabits it, makes use of it in that Capacity, mounting in it up to the Surface of the Water in calm Weather. He unfurls * a Membrane to the Wind, which serves him instead of a Sail, and extends two Arms, with which, like two Oars, he rows his little Bark along; when he has a mind to dive, he strikes sail, collects himself within his Shell, and filling the re-

* Costui da fatti naviga, alzando e distendendo una membrana, che gli serve di vela, ed allungando due Brachia batte l'acqua, e gli fanno l'uffizio di remi. Quando vuole immergersi, ammaina la vela, si ritira in se stesso, s'impie d'acqua, e senza timore di naufragio v'è al fondo, risalendo al sua libera voglia, laonde — senza avere appreso l'arte del Navigare, egli e nocchiero & nave di se stesso, ne in qualsivoglia parte che fosse il vento, di nulla teme: ne timone e l'arte fuor di se stesso ricerca. *Vallisneri saggio d'hister. nat.*

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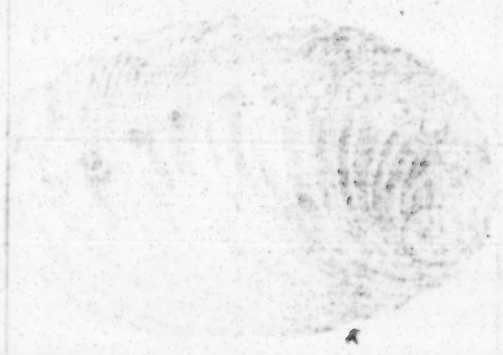
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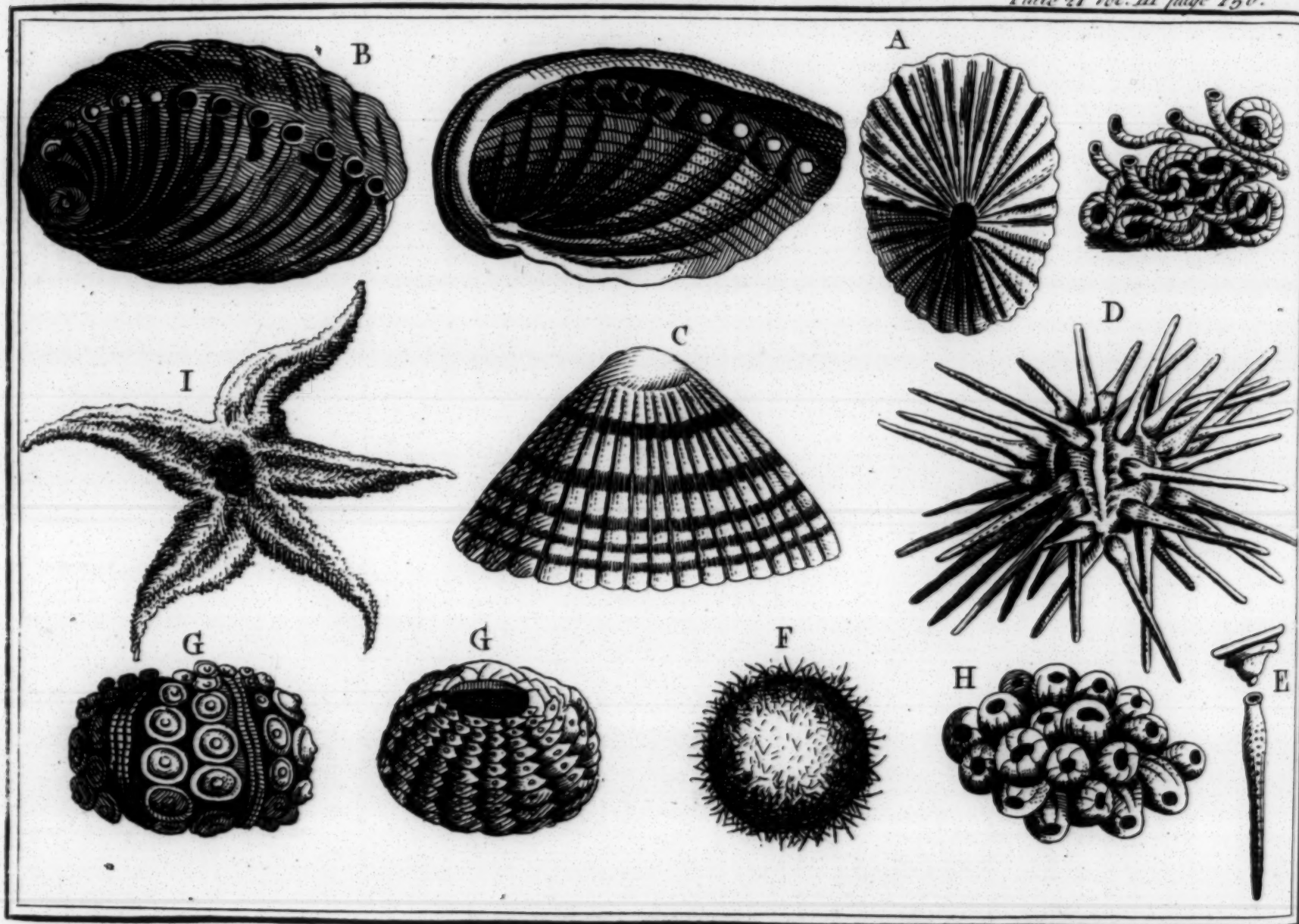
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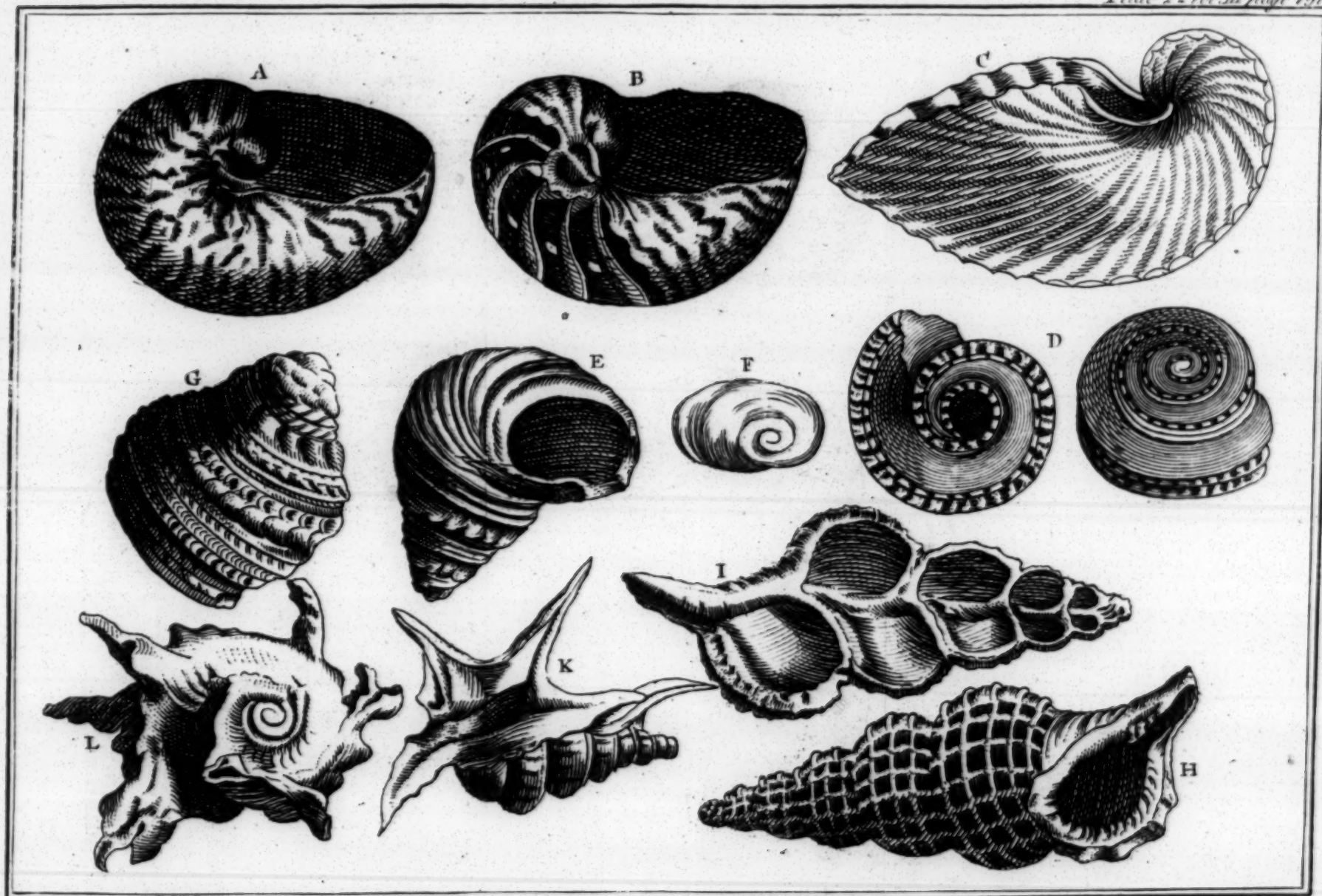




Shell-Fish having only one Shell.

Tome sculp.





Shell-Fish having one Shell and that Wreathed.

Ten's sculp.

maining Room with Water, without any Apprehensions of drowning, sinks to the Bottom. The Fish, by contracting itself, leaves a vacant Space in his Boat, into which the Water finds Admittance through a little Aperture, contrived in the different inner Chambers, which it removes out from Year to Year, as it enlarges its Boat in Proportion to the Increase of its Body. The Water being thus received into the Boat, does by its additional Gravity, cause it to subside to the Bottom: On the other hand, when the Fish has an Inclination to ascend to the Top, it is very likely that he dilates himself, extending the Extremities of his Body into those little Chambers or Cells, thereby forcing the Water in them out of the Top of the Boat; by means of which Evacuation, it becoming specifically lighter than the Water, must necessarily ascend. Thus it steers its Course, without Chart or Compass, self-taught in the Art of Navigation, and is at once both Pilot and Vessel. From whatever Quarter the Wind blows, it is all alike to our little Sailor, who is never under any Apprehension of Danger, nor ever destitute of Rudder or Oars, Cordage or Pump, having all proper Utensils of Navigation within itself.

Chevalier. Of a quite contrary Nature to the Sailor is the greatest Part of those Shell-Fishes that constitute the fourth Rank; for as the first is perpetually travelling from Place to Place, the latter remain all their Lives attached to one and the same Place, as your Limpets of every Species, and the Sea-Ear. But how they can live without seeking out for Provision, I cannot conceive, unless it be that their Prey comes to them of its own accord.

Limpets. *Patella*
or *Lepades*.

The Sea-Ear.
Auris marina.

Prior. I am apt to think that this is the Case, and that those Holes which are pinked along the Brims of the Sea-Ear, are designed as so many Traps wherein to catch every now and then some of those little Worms, that swarm at the Bottom of the Sea in such great Abundance.

Chevalier. The Painter has not been able in the fifth Line to dispose of a great Number of your single Shells, twisted in the Form of a Screw, and widening their

Univalves, or single Shells of a twisted Form.
Turbinata.

Wreaths from the Apex downwards ; but I find that out of that puzzling Variety which there is of them, he has culled out such as are most remarkable, as the Helmet-Shell, the Triton's Trumpet, the great and small Whirl. He has ranged also along with them those Shells that are round and smooth without, which do not seem to wind like the others. Their beautiful Make, and rich Colours, have gained them the Name of the Goddess of Beauty, or *Venus-Shells* ; unless we had rather trace the Original of this Name from a Fiction of the Poets, who give out, that as this Goddess sprung from the Ocean, so she chose a Shell of this Figure for the Sea-Chariot.

The Helmet-Shell. *Echinus convexus.*

The Triton's Trumpet. *Buccina.*

The Whirl. *Turbo.*

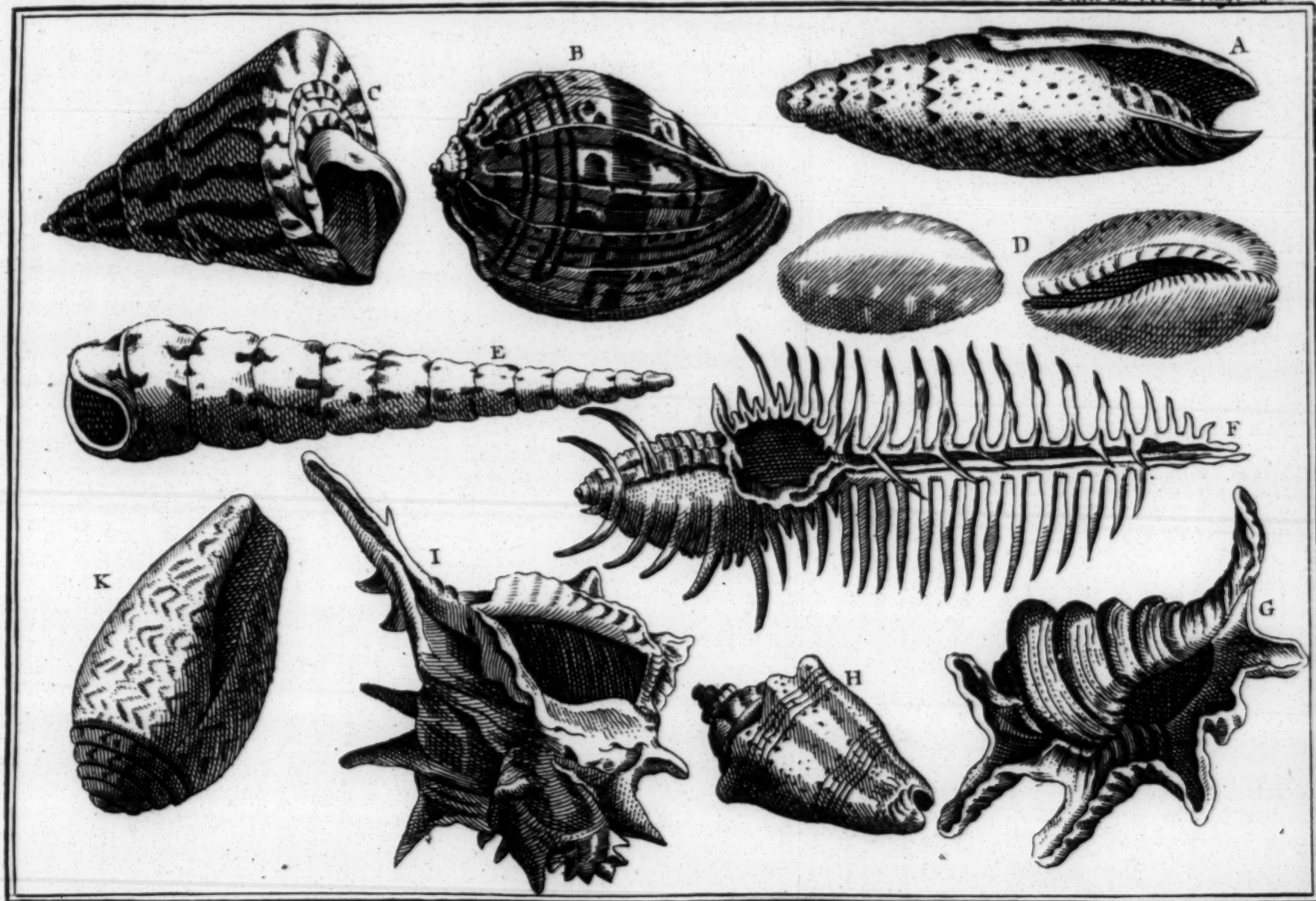
The Porcelain or Venus-Shell. *Concha Veneris.* There is a certain bivalve Shell also that goes by this Name.

The Purple-Fish. *Purpura, Murex. L'Emuri,* and the Observations of Father Plumier.

Prior. Here are some other Shell-Fish still more worthy our Regard, notwithstanding their rugged and bristly Aspect ; they are those from which the Ancients borrowed their purple Colour ; which was in all likelihood a white Liquor that this little Fish keeps in a sort of Bag or folded Tunicle which it carries on its Back, and which it sheds immediately as soon as you offer to take it from the Rock on which it crawls, and is lost if not caught with a great deal of Care. It dyes Wool of a very deep Red mixed with Purple, and never changes either by the Air or in the Washing ; but the Quantity of this Liquor in each of these Fishes is so very small, that an exceeding great Number of them will be only sufficient to dye one Piece of Stuff ; which was the Reason of the Purple's being set at so high a Value among the Ancients ; tho' the Cochineal of *America*, and the Kermes-Cods or Pustles of which they make Scarlet, are incomparably better and more lasting.

Bivalves, or Fishes with two Shells. *Bivalva.*

Chevalier. The following Lines of the Picture are still more entertaining than the foregoing ; they present us with all the different sorts of Shell-Fish that consist of

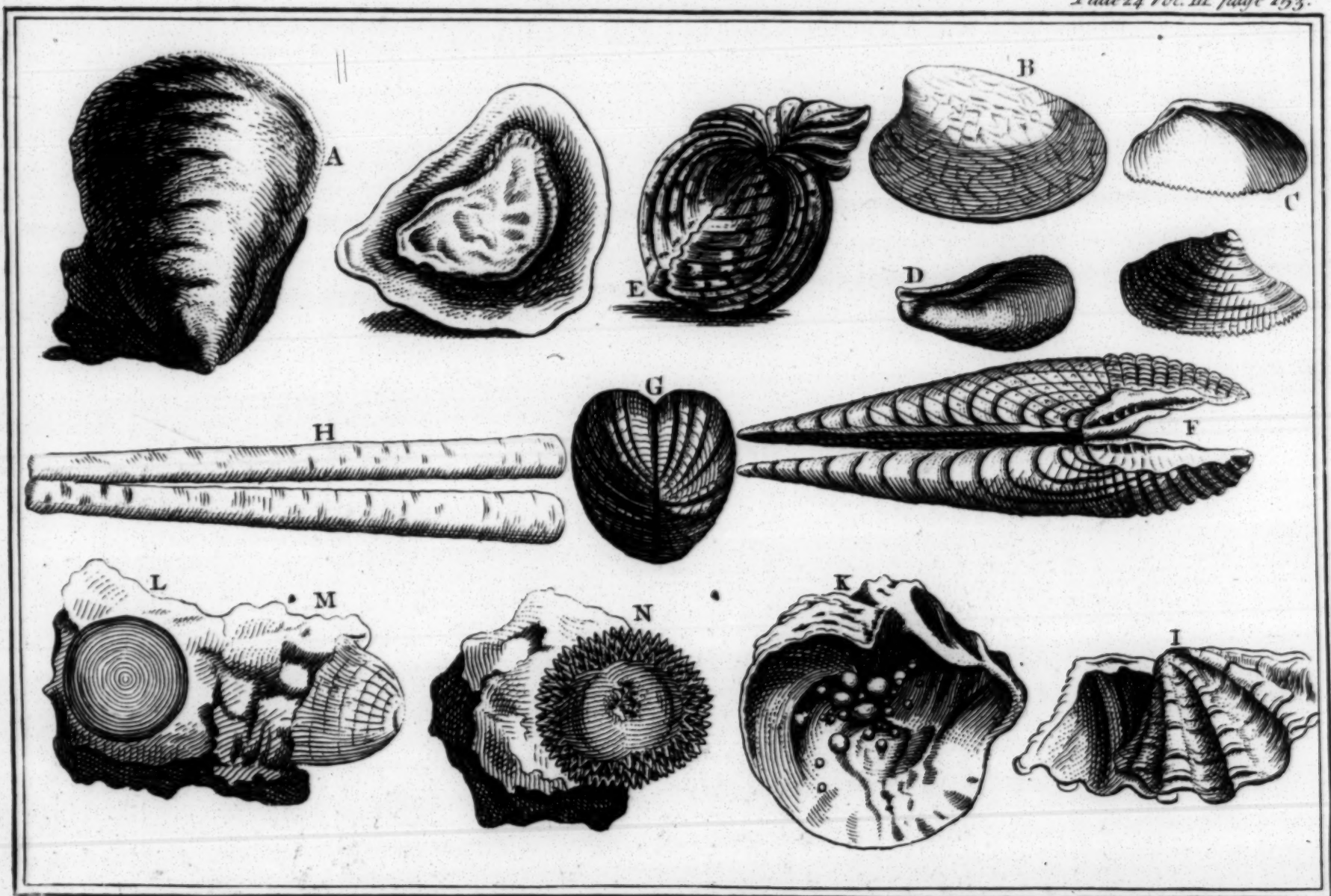


Shell-Fish having one Shell and that Wreathed.

Tom. sculp.

Shell-Fish having two Shells.

Plate 24 Vol. III page 153.



Toms sculp.

two Pieces, or open with two folding Doors. In the first Place you have the large Oysters and the green Oysters. What Pity it is that we have not the Originals here instead of their Pictures! To these succeed the Muscles and Limpins, which are not less esteemed than the former; and they are very judiciously placed here to set off the Largeness of the Sea-Wings that come next, which are again succeeded by Scollops and Cockles: These are generally the Decorations of the Collars of such Pilgrims as belong to the Order of St. Michael and St. James in Galicia. Amidst that Heap of Shells that follows these, I am not a little pleased with the regular Shape of those that resemble a Heart. This here that wears the Figure of a Hammer is reckoned a great Rarity; that other which you see opens like the Sheath of a Knife, and is called the Cutler, is more common. But of all the Shell-Fish there is none that commands our Admiration more than the Naker or Mother of Pearl. But pray what was the Design of the Painter in representing a Collection of Pearls of different Sizes at the Bottom of the Naker's Shell? Is it not in the Body of the Fish that they are found?

Prior. They are indeed sometimes found in the Bodies of Oysters, Nakers, and Scollops, but most commonly at the Bottom of the Mother of Pearl; and when plucked from the Shell, leave a Mark behind. Those which grow in the Body of the Animal seem to be nothing else but a kind of Gravel-Stone, whereas those which grow to the Bottom of the Shell are probably a sort of Warts or little Excrescences formed at first by a Defluxion or running over of that fine Juice with which the Fish first forms, and afterwards from time to time enlarges its Shell; and as this extravasated Liquor continues to distil down on these little

Oysters. *Ostrea.*Muscles. *Musculi.*Limpins. *Tellinae, Mytili.*The Sea-Wing. *Pinna.*The Scollop. *Pecten.*The Cockle. *Pectunculus.*The Cutler,
Razor or
Sheath-Fish.
*Solen, Digitus.*The Pearl.
Margarita,
*Unio.*The Naker or
Mother of
Pearl.
Concha margaritifera.

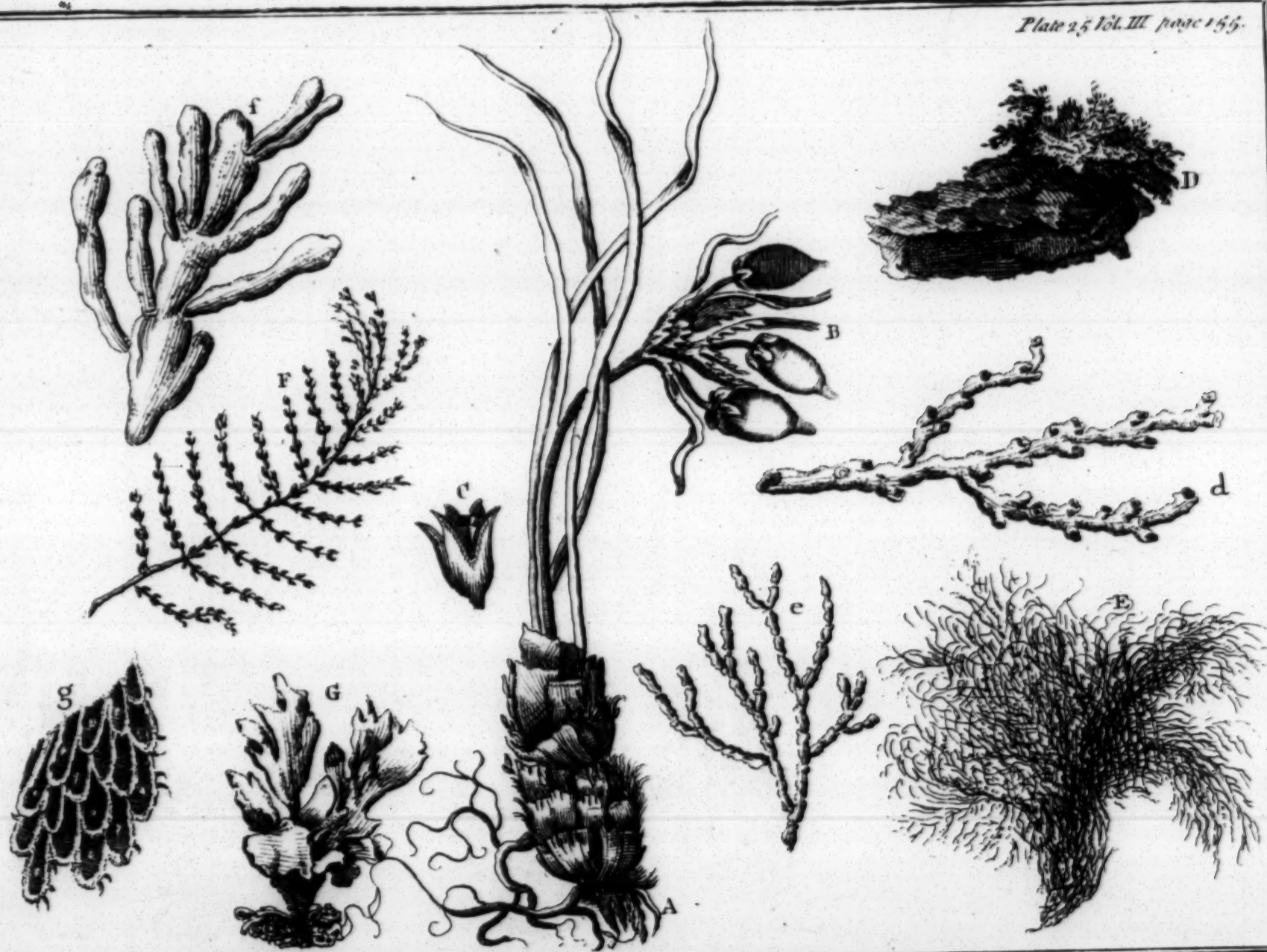
Globules, covering them with a new Coat or Layer of Matter, the Pearl grows proportionably bigger. Hence proceeds that Difference betwixt the large Pearls and those little ones, which are so improperly called Pearl-Grain or Pearl-Seed. Both the larger and the lesser sort receive either a regular Form, as that of a little Pear, an Olive, or a Globe, or else an irregular and angular one, according as the first little congealed Drop, which serves for the Kernel or Centre of the succeeding Layers or Tunicles, was of a regular or ~~an~~ irregular Figure.

The Wonders
displayed in
Shell-Fish.

We have indeed just Reason to be charmed with the Lustre and Beauty of these little shining Substances, though apparently they are nothing but a Discharge of an excrementitious Matter from the Body that produces them. But I cannot help admiring still more that delightful Mixture of red, blue, and green Colours, that so beautifully stain the Silver Ground of the Naker's Shell; though most amazing of all is that wise Design and Contrivance which appears not only in the Shell of this Fish, but even in that of the common Oyster and Muscle. The greatest part of these little tender Animals are of the viviparous Kind, and are spawned with the Shell about them, which Covering Nature has provided for their Security and Defence against the Assaults of other Fishes; she has also made them to abound with a sort of Slime or viscous Juice which they emit from their Bodies to the Extremities of their Shells; where it hardens into a Substance of the very same Nature, and by that means enlarges their Habitations proportionably to the Growth of their Bodies. Hence come those curve Lines, that we discern in the Shells of these Fishes, one without another, and which may serve as a Register, to shew the Number of their Years, and the different Stages of their Growth. There is also a surprizing deal of Workmanship in the Formation of that Hinge which joins the upper and lower Shell of a Muscle, as also in the curious and wonderful Movements of those little muscular Fibres and Ligaments with which it is fastened to them. When it has a mind to shut itself close up within its vaulted Cell, it discharges a
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Sea Plants

Wm. J. P.

certain Liquor into those Muscles, which causes them to dilate and swell, and consequently shortens their Length, and brings both the Shells, to which their Extremities are fastened, closer together. On the other hand, when it is disposed to open its Doors, at the Return of a new Tide, or the Fall of some kindly Shower of Rain, it withdraws that Liquor from them, thereby relaxing, and giving them a greater Length. But these are only probable Conjectures; for it is impossible for us to determine any thing certain of what is concealed from our Observation at the Bottom of the Sea: However, what we do see is sufficient to excite our Wonder and Astonishment at the indefatigable Pains and Industry whereby Nature preserves and provides for the meanest Creatures, and our Gratitude to the great Author of Nature for those innumerable Benefits which he so liberally bestows upon us.

Your Eyes, my dear Chevalier, seem very attentively fixed on this Picture; but believe me, it is high time to take our Leave of it; for should we enter into a particular Account of all these Tortoises, the Flesh and Spawn of which are reckoned so nourishing; the Sea-Acorns, which are held to be not inferior to them; these stony Tubes, which serve to lodge so many Worms; and especially were we to give a Detail of all those Sea-Insects with which the Painter has decorated the Borders of this Picture, the Day would fail us before we should get to the End of them: Let us therefore bestow a Minute on the Sea-Plants represented here in this next Piece. They are divided into three Classes, the soft, the half stony, and the stony Plants.

Picture XV.
Sea-Plants.

The soft Sea-Plants are the Orewood, or Grass-Wrack, Sponges, Mosses, Sea-Mushrooms, and some others. The Orewood, which grows with long Leaves like Laces, and the Sea-belt *, which is another kind of Orewood, the Leaves of which are scollopped like the Foliage of the Oak, are both very good to lay upon

The Orewood.
Alga.

* The Sea belt is called in Latin *Fucus*. There are several sorts of this Plant. See Dale's *Antiquities of Harwich*, &c. The Appendix, p. 341, &c.

Land to fertilize and improve the Soil ; the Ashes of them are also good to make Glas of, as well as those of the Kalt or Salt-wort, by reason of the Salts with which they abound.

The Sponge.
Spongia.

Every body knows the Use of Sponges, which are valued according to their Fineness. These two Sea-Plants are almost the only ones that are of any material Use to us. The others serve to adorn the Cabinets of the Curious, and are sometimes made use of in Pharmacy.

Half-stony
Plants or Lithophites.

The half-stony Plants or Lithophites, are those which partake of the Flexibility of Wood even after they are taken out of the Water, but by pounding are reduced to Powder like Chalk. There are numberless Kinds of the Lithophites ; some of them resemble a leafless Shrub, others wear the Form of a Net, sometimes with its Meshes quite open, sometimes closed up or gathered. The internal Substance of the Branches partakes of the Nature of Horn, and when burnt in the Fire smells like it: The Bark is of a stony Nature, and contains a great deal of Salt.

The Plants that are entirely stony are the Coral and the Madreporé ; the latter has no Bark, but the former has.

The Madreporé.
Madrepora.

The Madreporé consists of several Sorts ; sometimes it is like a flat Plate more or less thick, of a white stony Substance, pinked with a vast Number of Holes or Pores in the nature of Gutter-work, sometimes resembling Waves, Stars, Leaves, or other Figures ; though most commonly it wears the Form of a little Tree with its Branches studded with several little Holes.

The Coral.
Coralium.

The Substance of the Coral within is always of a stony, solid, and very hard Nature, even when it is in the Water, except the Extremities of the Branches, which are somewhat limber and flexible, and these too grow hard and petrify in the Air. The Bark or Rind of the Coral has in it a Mixture of Tartar and Glue ; it is a little rough and jagged, but will take a very fine Polish.

There

There is also a white Coral; but as to that which is called black Coral, it is a Sea-Plant, of a different Nature. The Coral, which the *Europeans* make little use of, is highly esteemed in *Asia*, more especially in *Arabia*, where, besides a vast Number of Toys that they make of it, as Spoons, Heads of Canes, Hafts for Knives, Sword-Hilts, Necklaces, and the like, the principal Use they put it to is the making Chaplets of Beads; the *Mahometans* of *Arabia Felix* regulating the Number of their Prayers by that of their Beads; and moreover they scarce ever bury any of their Dead, without having first encircled the Neck with one of these Chaplets.

On the Sides of the young Branches of Coral are found little Tumours or Ex- Coral Flowers. creescences pinked in the Form of Stars, and which, at their first being taken out of the Water, are replete with a sort of Milk. From within these Stars, the Count *De Marfilles* assures us he has discovered Flowers shooting out, but which withdrew again into them, upon the Coral's being exposed any time to the open Air. Many learned Men have been of Opinion, that the stony Sea-Plants consisted of nothing else but petrified Layers or Coats of Salt and Tartar, folding one over another as Chance would have it; and as Coral always grows with its Head downwards in little Caverns at the Bottom of the Sea, and on the Juttings out of Rocks, such a Situation confirmed them in their Suspicions, that these little Trees were nothing but petrified Substances, like those which are found sticking to the vaulted Roofs of certain Caves.

But since the Discovery of the Flowers of Coral, as also of some other Sea-Plants, there is no room left to doubt of their regular Organization; and if Naturalists have not yet been able to discern the Seed of them, it is owing to its Minuteness, which renders it imperceptible.

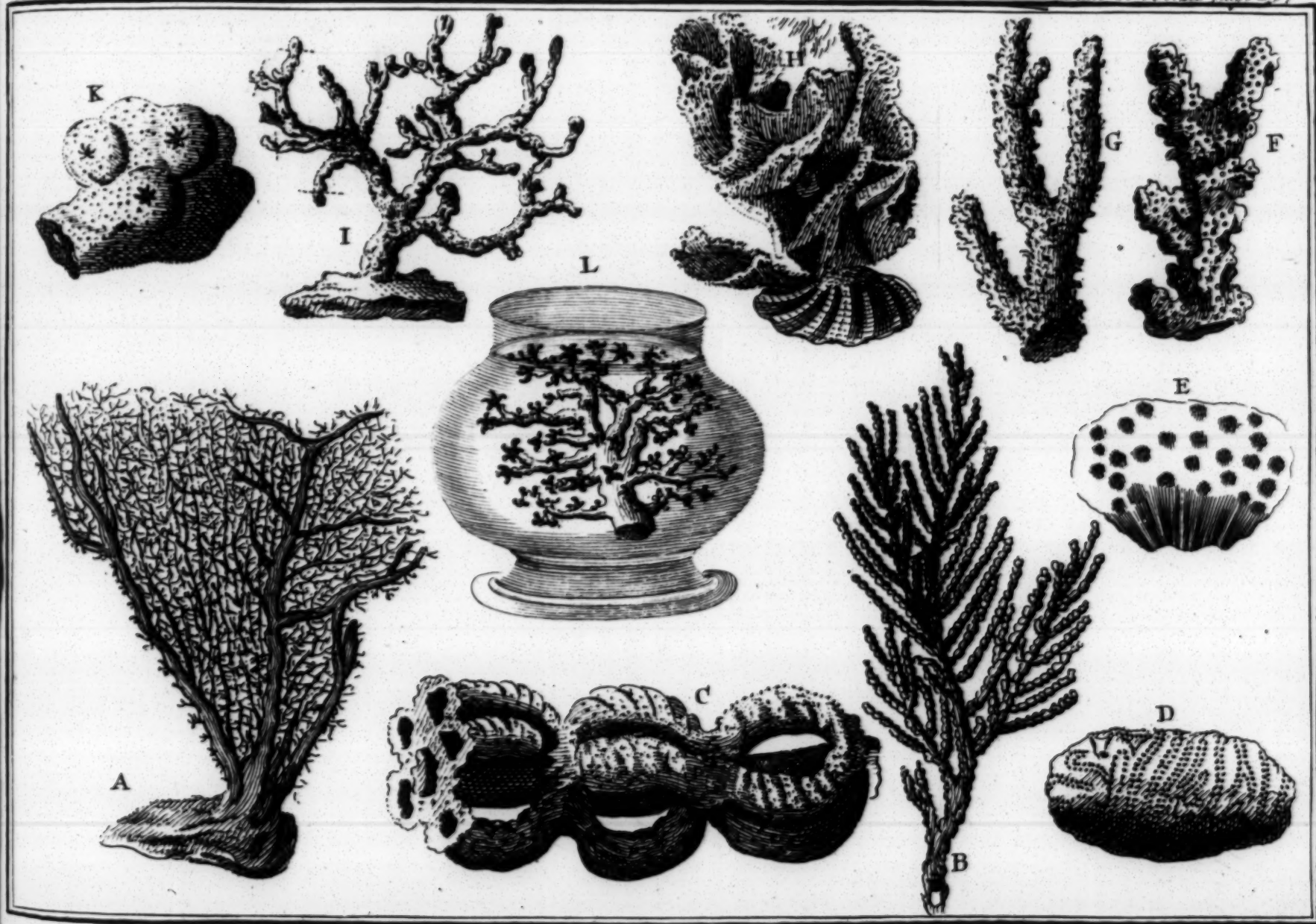
Chevalier. You just now observed to me, that the Coral always grows with the Head downwards; consequently, if it bears any Seed, it must, when come to Maturity, fall down to the Bottom of the Cavern; how comes it to pass then that this Plant never grows at the Bottom, where the Seed falls, but always on the Sides or Tops of the Clefts in Rocks, whither it cannot be carried?

Prior.

Prior. The Objection indeed is urged very home ; but to this I reply, that the Grain or Seed of this Plant is so very fine, that probably it is lighter than the Water ; besides, that milky Juice which envelops it, and is found at the Bottom of the Coral-Buds, being of an unctuous Nature, helps to buoy them up upon the Water. The Consequence of which is, that those Seeds which swim at random on the Top of the Water, perish and come to nothing ; whereas those that meet with Chinks and Creeks of Rocks in their Way for them to fasten to, unfold their Tunicles, and flourish into a little Tree. The Reason of their growing downwards is this : As the * Air causes our Plants to grow upwards, by descending directly through them from the Top to the Root ; the Water on the other hand causes the Coral to grow in a contrary Direction down from its Vault, by ascending through the Pores of this Plant up to the Root. Now from the Regularity of these Productions, from the Organization discernible in their Structure, from all the little Pores with which the Bark abounds, in order to give free Admittance to the Bitumen and other Juices of the Sea ; from those Tumours so † regularly studded with little Holes in the Shapes of Stars to enshrine the little Flowers of the same Figure ; from those Vessels replete with a milky Juice, which are found betwixt the Bark and the Body of the Plant, and which administer to the Nourishment and Growth of the Plant ; and lastly, from that constant Uniformity and Agreement in all the Particulars of Plants of the same Species, we may fairly conclude, that the Bottom of the Sea is covered with Plants of a quite different Nature from ours ; it has its Forests and its Meadows, wherein the Inhabitants of the Water find such Food as is convenient for them ; here they find a peaceful Retreat where they may conceal their Eggs, or secure themselves from the Tyranny and Persecution of the Fishes : And though these Plants be not of immediate Use to us, yet our Benefit was the End both of their Creation and Preservation, since they serve for the Nourishment, Retreat or Defence of such Fishes, Tortoises, and Shell-Fish,

* See Vol. I.

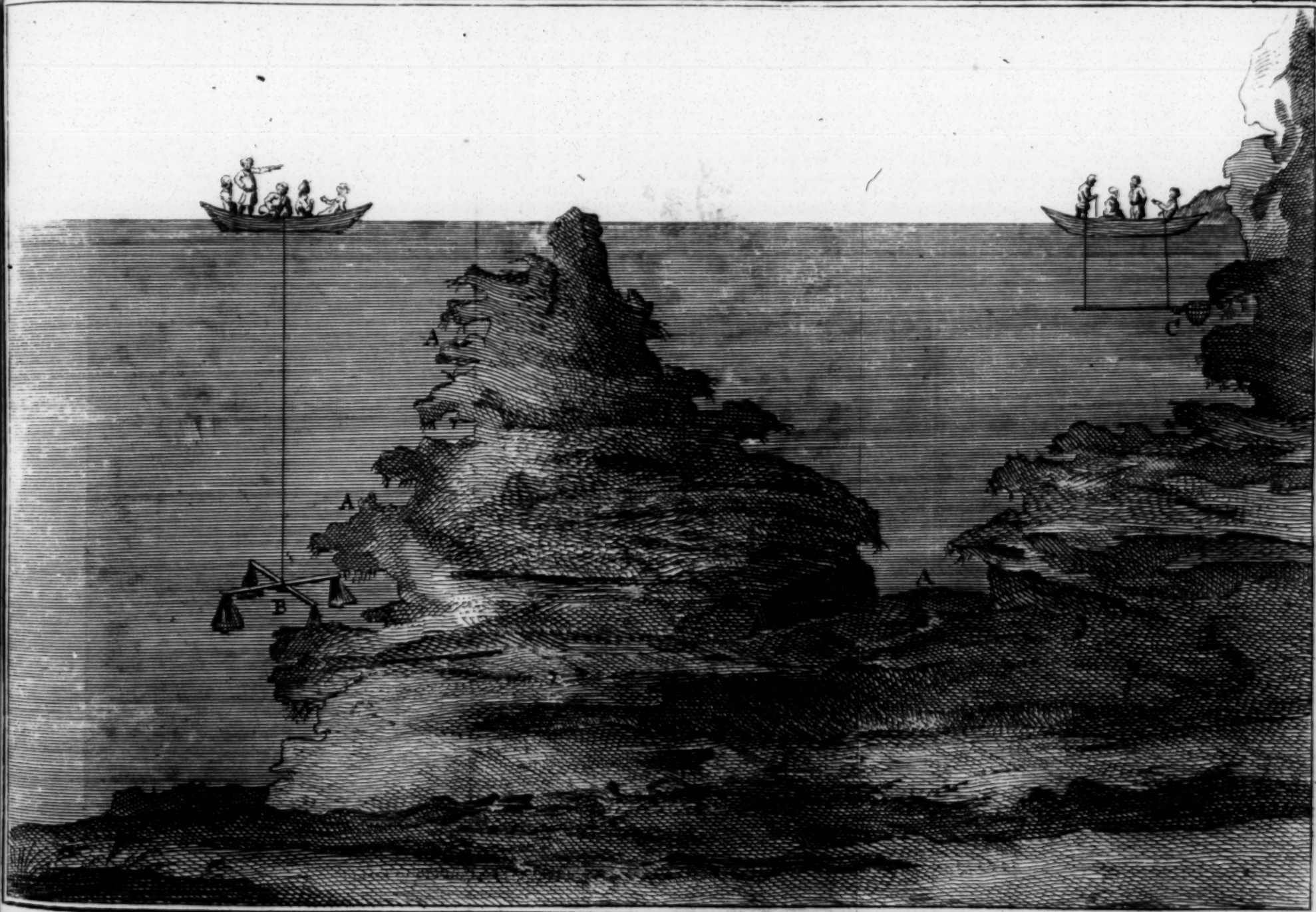
† This regular Disposition of the Holes in the Figures of Stars is very discernible in the Tumours of the white Coral.



Sea Plants.

Tom. sculp.

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Coral Fishing.

Tome sculp.

as supply our Tables both with Plenty and Dainties.

Chevalier. I am fully persuaded that all these Productions can never be the Effect of Chance, but are the Offspring of Contrivance and Forecast, though we receive the Benefit without thinking of the Benefactor. The only Difficulty I cannot get over, is to conceive how so many Plants can be nourished and grow without the Assistance of Earth; for all the Parts in this Picture, the Sea-Weed excepted, have instead of Roots nothing but a flat Bottom or Foot by which they stick to some Stone, Shell, or Piece of Wood.

Prior. Plants are endued with no other Organs or Parts than are necessary to their Subsistence. As our Land-Plants were made to live on those Juices which permeate the Pores of the Earth, or fluctuate in the Atmosphere, they are accordingly provided with Roots, Fibres, and capillary Vessels, to attract the Water which is under Ground, and also with Branches and Leaves to imbibe the Moisture that is in the Air: Whereas the Sea-Plants, which find in the Waters a sufficient Quantity of Salt, Oil, and such Spirits as are necessary for their Vegetation, have no Occasion for Roots to feed them with a Supply of Juices from under the Ground. In a word, whether we will allow them the Name of Plants or no, we must grant them to be regular Productions, which keep up the Continuation of their Species, and in which Chance has no more Share than it has in the Propagation of our Flowers and Fruits upon the Land; and though the Body of Water that covers them conceals from us the Manner of their Operation, the different Steps of their Progress and Growth, and the particular Uses they are appointed for; yet Reason can so far penetrate into the Mysteries of Nature, as to discern in those things that are in a great measure hidden from us, as well as in those that are fully discovered to us, fresh Proofs of an infinite Wisdom displaying itself in the Order and Oeconomy of the whole Universe, and making a liberal Provision for the Inhabitants of the Water as well as those of the Land; and in short, of a Providence that has so constituted and disposed every Part of Nature, as to make it most effectually conduce to the Benefit of Mankind.

The A I R.

DIALOGUE XXIII.

The PRIOR and CHEVALIER.

Chevalier. **E**Very Step that I advance in the Knowledge of Natural History, seems an Addition to my Fortune ; and I begin to think myself in Reality, a Proprietor and King of all the Earth, since by the Assistance of Navigation, I can take Possession of the Productions of every Country of the World.

Prior. You are not of the same Opinion with those who fancy they possess none of those things, which they enjoy in Partnership with others, and which they are not sole Masters of : Your way of thinking is not only more generous, but more true than theirs ; for in order to be rich, it is not necessary to be surrounded with those that are indigent and necessitous, nor does our Happiness consist in other People being miserable. Several Brothers are content to enjoy a Lordship in common, that is sufficient for the honourable Maintenance of them all ; and in this Sense you may truly be said to share the Lordship of the whole Earth, seeing for you the Eastern Spices exhale their Sweets in the Port of *Amsterdam* ; for you Coffee is imported at *Marseilles*, and Sugar at *Roban*. It is true, you must pay for the Share you have in these ; but don't you also pay for the Labour of the Husbandman that tills your Ground ? The Merchants that sail to the most distant Parts of the Earth, to fetch for you the various Produce of various Climes, are so many voluntary Labourers
an

and Servants, and who have therefore just Claim to a Reward for their Services; you can neither reap nor import the Fruits of foreign Countries of yourself, and therefore ought to recompense those who take this Trouble off your Hands.

The farther you advance in the Knowledge of your Riches, the more you are convinced that all Nature is one Whole; the several Parts of which are mutually aiding and assisting to each other, having been connected together by infinite Wisdom for our Use and Benefit; nay, so intimate a Relation and Dependence subsists between all the Parts of this great Work, that not any of them could be annihilated without destroying the Whole, at least, without defeating the End for which it was created. For Example: You looked upon the Sea, a little while ago, as a fortuitous Collection of Waters, that was rather a Hindrance and Disadvantage to Mankind than otherwise; whereas, should the same Power that created the Sea once dry it up again, we should not only lose that Tribute which we receive from the four Quarters of the World, that is to say, the principal Comforts of Life, but even Life itself, inasmuch as it is to the Sea alone we owe that universal Distribution of Water and volatile Salts, which are the two fundamental Principles of Vegetation, and the grand Cause of the Earth's Fruitfulness.

Chevalier. I remember, Sir, it was your Remark, that the Sea afforded the Water which was necessary to Evaporation, and that the Air performed the Office of a Pump, in raising and distributing the Water for our Use. This is indeed an Operation that gives Life and Vigour to every Part of Nature, though at the same time we are ignorant of the Manner after which it is performed; for though we see the Water ascend and descend through the Regions of the Air, yet we do not see the Air itself. Pray, Sir, is it possible to give me any Insight into the Nature and Mechanism of this Pump that we are so much obliged to?

Prior. This was my Design. You know there are in the Neighbourhood five Ecclesiasticks who have formed themselves into a little Society, and have admitted me a Member of it. We meet once in a Week to discuss some

some Point of Ecclesiastical History, and one of Natural History: At our last Conference the Conversation turned on that Topick which is the present Subject of your Curiosity. Here is the Discourse which was then read in Company.

Chevalier. I am impatient to peruse it.

Prior. Let us first read it all over; only do you by the way mark with your Pencil those Places which you do not understand, or have any Objection to, and we will consider them particularly afterwards.

The Chevalier reads.

A DISCOURSE *on the* PROPERTIES of the AIR.

SINCE a thorough Acquaintance with the Nature and internal Configuration of the Parts of those Bodies we do see is not attainable by us, much less ought we to flatter ourselves that we shall be able to comprehend the inward Structure of those Bodies which we cannot see; such is the Atmosphere, or that Body of Air that surrounds us, and which we breathe; for though we see the Clouds, the Lightning, the Rain, the Hail, and other Meteors that are formed therein, and act with great Force and Power, yet all these Bodies are of a quite different Nature from the Air. That also which we perceive in a *Camera obscura*, or darkened Chamber, into which only one of the Sun's Rays is admitted, is nothing but a Collection of some Particles of Dust floating about in the Air, which reflect the Light from their several Surfaces; whereas the Air itself is a Substance of such extreme Fineness and Tenuity, as render it imperceptible to the Eye, though assisted by the best Microscopes; but notwithstanding its Invisibility, yet it sufficiently discovers itself, by the Regularity of its Effects, to be as complete an organized Body as any that we see or feel.

The

The chief Properties of the Air are Fluidity, Gravity, and Elasticity. In the first Place, the Air is a Fluid, or consists of Parts of a globular Figure without any sensible Attraction or Cohesion betwixt them, and which therefore easily glide one over another, yielding to the most slight Impression. We need no other Proof of this, than that Ease and Freedom with which Animals breathe this Element, and pass through it without any Molestation or sensible Resistance. Secondly, That the Air does gravitate or act upon inferior Bodies by its Weight, is demonstrated by ten thousand Experiments: We will content ourselves with giving one that is very common. Take two Tubes, one of Tin forty Feet long of any given Diameter, and another of Glass four Feet long, both stopped up at one End: Fill the Glass Tube with Quick-silver, and then invert it, immersing the open End of the Tube in a Bason or other Vessel filled with the same Fluid, so that the closed End may be uppermost and perpendicular to the Surface of the Quick-silver in the Bason: The Tube being thus situated, the Mercury or Quick-silver will run out at the open End of the Tube into the Bason till it comes down to be but twenty-seven or twenty-eight Inches above the Surface of the Fluid therein contained; at which Height, notwithstanding the great specifick Gravity of the Mercury, it will remain suspended in the Tube. Now it is certain, that nothing can sustain the Weight of the Mercury in the Tube, but a Counterpoise on the remaining Surface of the Fluid, which, by all Discoveries, can be no other than that of a Column of Air of the same Diameter with the Orifice of the Tube pressing on every other equal Part of the Fluid's Surface, and which not being counter-balanced by any Air in the Tube, raises, or suspends when raised, a Quantity of Mercury equal in Weight to itself, in order to constitute an Equilibrium. And this appears certain from hence, that if you open the upper End of the Tube, which before was closed up; in this Case, the Air pressing on the Mercury within the Tube with as much Force as it does on the Mercury without the Tube, the former will subside to the Level

The Fluidity of
the Air.

The Gravity of
the Air.

of

of the latter. The Experiment holds equally good in a Tube forty Feet long; the only Difference is, that as in the former it is made with Quick-silver, in the latter it is made with Water. Take the Tube forty Feet long, and fill it with Water; then invert it, immerging the open End in a Vessel filled with the same, as in the former Case; upon which you will find that the Water, instead of running all out of the Tube by the Force of its own Gravity, will not descend more than some few Feet from the Top, but remain suspended at the Height of about thirty-two Feet above the Surface of the Fluid in the Vessel, being sustained by a Column of Air of the same Diameter, the Pressure of which on the Surface of the external Water is equal to that of the thirty-two Feet of Water in the Tube: Now as upon opening the Top of the Tube, the Weight of the super-incumbent Column of Air pressing upon the 32 Feet of Water in the Tube, and that of the Water itself together, are double the Weight of a Column of Air alone of the same Diameter, pressing on the Surface of the Water without the Tube, the Water before suspended must consequently descend into the Vessel to restore an Equilibrium, which we accordingly find it does, not so much as a Drop remaining behind in the Tube. Thus we may be able to know the exact Weight of a Column of Air, whose Diameter is the same with that of any given Tube, and whose Height that of the whole Atmosphere from the Surface of the Earth, it being equal in Weight to a Column of Water of the same Diameter thirty-two Feet high, or to a Column of Mercury twenty-seven Inches high; and according as the Column of Water or Mercury, whose Altitude we measure by Feet and Inches, is of a larger Circumference towards the Bottom, the Base of the Column of Air is proportionably increased, and consequently the Weight of it. So that we have nothing to do, but to know the Weight of the one, in order to find out that of the other.

The Elasticity
of the Air.

Nor is the Elasticity of the Air less demonstrable than either its Fluidity or Gravity. We call a Body elastick, when upon being compressed it has a natural Tendency to relax itself, or recover its former Posture.

Now

Now that this Property is inherent in Air, appears from the following obvious Instance.

It is a common thing in the Glafs-Houses to make a sort of little hollow Glafs-Globes with one Hole in each of them; into these they thrust a Glafs-Tube almost to the Bottom, fastening it to the Orifice of the Globe with Mastich, so that no Air can pass between. This being done, they immerse the *Æolipyle*, or Glafs-Globe with the Tube inserted into it, in the Water, till the *Æolipyle* is half full of Water and half full of Air, or thereabouts: Then they blow with all their Might in at the Neck of the *Æolipyle*, till they have forced as much more Air into the Body of it as was in before, the first Air contracting itself to make room for the second. This little Body of Air being thus compressed and imprisoned within the Sides of the Glafs-Ball and the Surface of the Water, endeavours to get loose and expand itself with so much Violence, as to force the Water above it out of the Top of the little Tube, making it to spout up into the Air three or four Foot high. So great is the elastick Power of three or four Inches of condensed Air. But still more extraordinary are the Effects of this Property of the Air in a Wind-Gun. Into the Bore of this Engine they force a certain Quantity of Air by the help of a Pump, or Syringe, which Air they imprison in the Barrel by turning a Cock placed for that Purpose at the Extremity of it; then they condense it still more and more by ramming it hard down with an iron Rod. This done, they open a Cock at the other End of the Gun, after having put a leaden Bullet into it; upon which the confined Air rushes forth with such a Violence as to force the Bullet, which it drives before it, through an Inch Board, and would kill any Man that should be so unfortunate as to be in its way.

Having thus proved by the foregoing Instances, that the Air is endued with Fluidity, Gravity, and Elasticity, we may next inquire a little into the principal Causes and Effects of these Properties. Now the Fluidity of the Air, like that of all Liquids, does probably proceed from the Action of some more subtle Body, that pervades and separates the Parts of the other. Thus Gold and Silver are put into a State of Fluidity by the Action of Fire,

Fire, which penetrates and dissolves the Parts of these Bodies; and accordingly we see, that when the Heat is dispersed, or the Fire ceases to act, the Parts of the Metal unite and cohere together again, and form one solid Body as before. To the same Cause we may ascribe the Fluidity of Water, it not being a fluid Body of itself, but is made such by certain Particles of Fire or Air, which insinuating themselves between the Particles of the Water, do by their Activity keep it in a constant State of Motion and Fluidity; and pursuant to this Hypothesis, we find that when the Spring and Action of the Air is in a great measure destroyed by excessive Cold, the Particles of the Water settle into a State of Rest, and form that consistent Body which we call Ice. Nor is it absurd to suppose, that the Air itself is a Fluid only by means of the Interposition of a very subtle active Matter between the Parts of it, and in which it swims. This subtle Matter may be called *Æther*, and is probably endued with this active Power to give Vigour and Motion to the other Elements, even to the Fire itself: The Parts of this *Æther* are of so exceeding fine a Texture, that it gains a free Passage through those Pores with which all Bodies do more or less abound without destroying the Cohesion of their Parts; but meeting with Resistance from the Air, it does by its Impulse keep the Parts of it in a State of constant Motion and Fluidity.

The Gravity of the Air, as well as that of all other Bodies, does arise from that Harmony which God has established in the World, having ordained by an universal Law, that all the Bodies that compose the material System should have a Tendency towards the Centre of that System; and secondly, that the Degree of their Acceleration should be in Proportion to their respective Densities, and to the Resistance they meet with from those Fluids they pass through. From the first Law * it follows, that a Feather and a Ball of Lead should descend with equal Velocity, when not obstructed in their Descent by the intermediate Air; whereas in the Water or the Air they will descend with different Degrees of Velocity according

* See the Experiments made before the King of England. *Philos. Transf. abridged by John Lowthorp, Tom. 4.*

to their different Densities. By the same Law it would likewise follow, that all the Air in the Atmosphere should descend upon the Earth, and form one consistent Mass of Matter; but that, by a Consequence of the Second, the Æther which serves as a Medium to the Air, and wherein it floats, prevents its descending by communicating to it Motion in contrary Directions; so that the Gravity of that vast Body of Air that surrounds our Earth becomes very inconsiderable, and adapted to the Constitutions and Necessities of those that breathe it. Hence we may observe how the great Creator of the World, who has impressed on all Bodies a Tendency of Motion towards the Centre, and has regulated the Degrees of their Velocity towards the same, has also established the most exact Order and Harmony, by assigning to every Body its proper Place and Station. And as all the Bodies of the Universe did at first obey the Almighty's *Fiat* when he called them out of nothing, so are they no less obedient to those Laws by which he has regulated their Motions and Offices to all Eternity.

The Elasticity of the Air results from the particular Structure of it. It is very probable that every Particle of the Air consists of several Leaves or Folds like a Book or Pair of Bellows; and consequently the Air must swell and dilate itself in Proportion as the æthereal Matter or the Fire insinuates itself betwixt these *Laminæ* or Folds, and on the contrary contract and shut itself as it is evacuated from between them. This Texture, which we suppose the Air to be of, is indeed only Conjecture; and perhaps such a Solution of this Phænomenon does fall as far short of the Handy-work of God in this Particular, as his Thoughts are superior to ours; but however unable we are to give any satisfactory Account of the Spring and wonderful Mechanism of that Air we breathe, by our most exact Researches into the Structure and Constitution of it; yet the Consideration of its different Effects will not fail to give us a more exalted, as well as a more adequate Idea of the Nature of this Element.

The most general Effects and Properties of the Air are the Evaporation of the Waters, the Formation of Winds, the Vegetation of Plants, and Digestion and Nutrition in Animals. The Air is also the Vehicle of Sounds, of Smells, and of Light.

The Evaporation of the Waters, which is so necessary and constant an Effect of the Air, seems at first View impossible, and contrary to Reason; for since the Water is a Fluid of much greater specifick Gravity than the Air, how can we suppose it capable of ascending in a lighter Fluid, or of being sustained by it?

Nothing can convey to us so true an Idea, both of the Cause and the Effects of this Phenomenon, as a Diversion very common among Children: They make a Lather of Soap and Water, and taking a Drop of it on the End of a Reed, or Tobacco-Pipe, blow it full of Air, till by degrees it swells into one of those large Bubbles of various Colours, that affords them so much Entertainment. The Operation is performed in the following manner: The little Artificer who makes the Bubble, blows into it through the Reed or Pipe-part of that warm Air before contained in his Lungs: The Heat which before rarefied the inspired Air, does also rarefy that in the Drop of Water; which being dilated and increased by blowing in fresh Air, repels from it those grosser Particles of Matter, which obstruct its Dilatation, as the Water, the Oil, and other Ingredients, of which the Soap is composed. Now as the external Air does equally on every Part resist the Action of the internal Air, consequently the Fire, and rarefied Air contained within the Bubble, have not a rectilineal, but circular Motion, forming a kind of Vortex, the Extremities of which are possessed by the Water and the Oil, which being repelled by the Air within, and compressed by the external Air, constitute a little smooth concave Sphere, which grows thinner and thinner in Proportion to the Increase of its Diameter. Now as the rarefied Air that occupies the Space within the Bubble, does, together with the oily and aqueous Particles that compose the Surface of it, constitute a Body which is lighter, or at least as light as an equal Bulk of Air not rarefied, it will remain

remain suspended in the Air, or rise, fall, or move horizontally, according as any the least Impression of the Wind gives it a Direction. This is a just Representation of the Action of the Sun and Wind on those Parts of the Earth and Water, that are exposed to their respective Influences.

The burning Matter which the Sun darts upon the Earth, as it finds easy Admittance through the Surface of all fluid Bodies, insinuates itself into the Folds and Interstices of the Air *, which gives Fluidity to the Water, thereby rarefying the Air, and consequently those Globules of Water in which it is inclosed. These fiery Particles being reflected back from the Surface of the Earth and Water, carry with them those little watery Bubbles, into which they insinuate themselves, and together with them several Corpuscles of a different Nature, that happened to be intermixed with them, as of volatile Salts, Oils, Sulphur, Bitumen, Minerals, and many others, which either proceed from the Flesh of Animals, or are discharged from the Bowels of the Earth, and from Mines into the Sea, where they either mix with the Water, or swim on the Surface of it, like a Froth or Scum, more or less perceivable. The Fire and rarefied Air occupy the Inside of the Bubble, while the Water and the other gross Particles, which are repelled on every Side from the Centre, go to form the Shell or Outside. These little Globules thus formed, being lighter than so many equal Bulks of compressed Air at the Bottom of the Atmosphere, must necessarily ascend into those Regions, where the Air is of the same specifick Gravity with themselves, where they remain suspended.

Now it is certain, that the Water cannot arrive at this Degree of Lightness, but by the Rarefaction of the Air contained in it; nor is the Air thus rarefied, but by the Action of the Fire which insinuates itself between the Parts of it; nor can any other Reason be assigned for the Ascent of these little Globules in Vortexes, but that natural Tendency, which the inclosed Particles of Fire have to ascend in spiral Lines; and this Direction of Motion is still farther promoted by the equal Pressure of the circumambient Air.

* See pag. 166.

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That these Bubbles have a real, and not only an imaginary Existence, is plain from hence, that several of them may be distinctly discerned ascending from the Surface of boiling Water, while those smaller Bubbles, whose Fineness renders them imperceptible, constitute that Steam which evaporates from it.

After knowing the Manner how Evaporation is performed, it is no hard Matter to discover what are the Effects produced by it. The Bubbles which are thus formed by the Heat, and made to ascend in greater or lesser Quantities, remain suspended in that Part of the Atmosphere, where the Body of Air beneath them is more dense, and that above them more rare, than themselves. This Collection of Vapours appears at a Distance like a

Clouds. solid Body, and is what we call a Cloud, though Travellers have found by repeated Observations, that the thickest of those

Clouds which they have seen from the Bottom of Mountains, gathering on the Tops of them, were, upon climbing up to their Summits, nothing but Mists, resembling those which we see every now-and-then settle upon the Plains.

The Winds that put the Air in Motion, be their Cause what it will, conspire with the different Degrees of its Rarefaction or Condensation, to determine the Course, the Gathering, the Clashing, and the Separation of the Clouds.

When the Bubbles that are scattered up and down in the Atmosphere meet with a cold Air, and which has more Power to compress, than the inclosed Fire has to dilate them, the Particle of Air that is in the Centre of each Bubble, contracts itself, causing the Bubble to do the same. Now the same Quantity of Matter, upon Condensation, taking up less room than before, every Bubble becomes heavier than an equal Bulk of Air, and therefore by the known Laws of Hydrostaticks must subside; consequently, in Proportion to the Weight of

Mildew.
Dew.
Small Rain,

these Bubbles above that of Air, they will descend with greater or less Velocity in the

the different Forms of Fogs, Mirkew, Dews, or small Rain.

If these Bubbles in their Descent meet with an Air so cold as to freeze them, they condense into Flakes of Snow of different Sizes; and as Snow does always consist of Oil, volatile Salts, and a Particle of Fire shut up in the Centre of this little congealed Body, it must necessarily follow, that the Land on which it falls, must be enriched and fertilized by it. / And this is found true by constant Experience. If there be really any Air pent up within these Flakes of Snow, so as to constitute a little hollow Body, whose Crust or Shell consists of congealed Water, the Consequence would be, that when the Snow comes to melt, and the confined Air, that before extended its Dimensions, to be set at Liberty, the dissolved Water, that before constituted but a Part of it, must occupy a much less Space than the Snow did; which is a Truth confirmed by Experience, and consequently an Argument of the real Existence of those Bubbles or Vesicles, by which we accounted for Evaporation. We will pass on now to the other Changes and Modifications that they undergo.

When a Torrent of Air happens to force one Cloud with a violent Shock against another, a great Part of the Bubbles burst, and dash one against another, forming themselves into larger or lesser Drops of Water, according to the different Force with which the Winds act upon them, either in a perpendicular or horizontal Direction; and the greater the Height they fall from, the more they coalesce by falling within the Sphere of each other's Attraction, and incorporating as they fall; which is the Reason why that Rain is for the most part very small, that descends from those Clouds that are low and near us, whereas it falls down in large Drops from those that are at a great Height above us. Now as the Atmosphere consists of several Regions, one above another, whose Temperament and Disposition varies according to the different Qualities of those Winds that agitate it, it often happens that those Drops of Rain, which are formed from an Association, or Coalescence, of these little broken Bubbles or Vesicles, do in the Course of their Fall, pass through

Snow.

Great Rain.

Hail.

some Region of the Air, cold enough to freeze them, which constitutes what we call Hail: Now the Size of the Hail-Stones is always according to the Size of the Drops of Rain congealed in their Fall.

Meteors in the Air.

From those fiery Particles lodged in the Centre of the Bubbles before-mentioned, and from the different Particles of Oil, Sulphur, Nitre, and other combustible Matter, carried up into the higher Regions of the Atmosphere along with the rarefied Vapours, is formed an inflammable Substance, which becomes more or less visible, according to the different Strength of the Composition, and the Quantity of it. If the Quantity of fiery Particles, issuing from the Bubbles of Water, upon the Collision of two Clouds, be very small, forming only a little Globe of Fire, which shoots out into

Falling-Stars.

a Train of Light in the Air, and straightway disappears, this is what the common People call a Falling-Star.

When the Flash is projected through a large Extent of Air, or sets Fire to a Train of other inflammable Matter, which happens to be within the Sphere of its Action, it is what we call Lightning.

Lightning.

When the Lightning descends in great Flashes, like an impetuous Torrent of Fire, it is what we call a Thunder-Bolt; and this has different Effects, according to the different State and Disposition of the Air, and the different Force and Proportion of those Ingredients, which enter into the Composition of the Lightning.

The Thunder-Bolt.

Thunder.

The Air which gets loose from those broken Bubbles in which it was before imprisoned, and that which happens to be pent in betwixt the Clouds, is necessarily very much dilated by these inflammable Substances; and therefore being hemmed in on every Side by thick Clouds, which contrary Winds heap together round it, or by the falling in of one Cloud upon another, does by its expansive Force, burst its Passage through them with a violent Exploſion, and causes that Crack or Rumbling which we call Thunder.

The

The Clap seems continued or reiterated, by reason of the Sound being reflected from the Surfaces of different Clouds, which causes so many Repetitions or Echo's.

The Length of the Clap.

As soon as ever the Fire breaks loose from the Bubbles, and kindles the other combustible Matter it meets with, the Air being thereby expanded, and put into a violent Agitation, rushes impetuously against the neighbouring Clouds, which being violently compressed by the Force of the Impulse, the Bubbles of which they are composed break, and discharge their Fire likewise in all Directions; which necessarily causes a Succession of Flashes, and makes the Rain pour down with greater Vehemence than before. And this is generally the Case immediately after the Thunder-clap *.

The Increase of the Rain.

Though Winds very often proceed from under the Earth, where they are formed by a Stream of Air, rarefied by the subterraneous Fire, and violently impelled upwards; yet there are also Winds which issue out of the Clouds, and make terrible Havock in a very little Compass, beating perpendicularly upon some Places, and whirling round in Eddies, without doing any Damage in Places that are contiguous. And these are occasioned by the Eruption of the Air, from the Bubbles of Water in the Atmosphere, which acts with the greatest elastick Force, where it meets with the least Resistance from the Clouds. Hence come those strange and mischievous Effects, which are produced by Winds in times of Thunder and Storm. The first Wind that drives before it the Body of the Cloud, generally blows in an horizontal Line; it very often happens, that at the same time, there blows from another Quarter of the Atmosphere a contrary Wind, which causes the Clouds to meet, and dash one against another; and after the Lightning and Thunder-clap, we often feel the sudden and terrible Shock of a third Wind, which is that Air discharged from the middle of the Cloud in the manner we just now related. This last Wind is always hot and suffocating, and brings with it a very noi-

The Winds.

* — Ingeminant Austri & densissimus Imber. *Georg.* 1. ver. 333.

some Stench of Sulphur; which plainly denotes the Nature of those Materials, that ascend together with the Vapours into the upper Regions of the Air. When this rapid Blast of Wind in its Descent passes through any inferior Strata of Clouds, whose Bubbles have been condensed by the Cold into Hail-stones, it darts them down on the Earth with incredible Velocity, like so many Bullets, which oftentimes do more Execution than the Thunderbolt itself. When other Winds besides these, issuing from the neighbouring Clouds, fly to the Fight with whizzing Speed, and join their adverse Forces,

Whirl-Winds.

the Hurricane straight arises, the Air whirls round in rapid Vortexes, the Smoak descends, the Dust flies, the Darkness gathers, the Rain pours down in Torrents, the Lightning, the Hail, and Thunder, all conspire to spread Horror and Consternation all around; the flowery Meads, the Corn Fields, and even whole Countries are laid waste, and all the varied Scene lies buried in one promiscuous Ruin. Now can these Irregularities, which seem to put Nature into a general Confusion and Disorder, be the Work of an all-wise Creator? But let us not dare to call that Irregularity, which is as much the Effect of Foresight and Counsel as those

The Usefulness
of Storms.

Laws of Motion which caused it; and Thunder and Storm are as much the Work of God, as the Fruits and Flowers that enrich and adorn the Earth. The most nauseous Drugs are the Product of his Creation, as well as the most delicious Dainties; and he is obeyed and honoured by Storm and Tempest, as well as by the gentle Zephyrs. There is not any one of his Creatures, in which he is not glorified; for they all faithfully perform his Commands, and extol his Power: *There is neither Speech nor Language, but their Voices are heard among them* *.

The Sun, which by its genial Warmth cheers and animates the whole Creation, leads us to the Worship of him, who is the Author of Life and Being: The Light

* ——— Tota concors Fabrica personat
Dei tuentis cuncta Potentiam,
Non Voce quæ paucorum ad Aures
Perueniat Strepitu maligno.

Buchanan, Psalm 18.

which.

which embellishes and adorns every Part of the Universe, is a lively Representation of him who is the very Essence of Beauty and Comeliness; the Rivers, the Forests, the Verdure, and Fruits of the Earth, do all declare the Goodness of God, and are so many Instances of his Love and Bounty towards us. But the Voice of his Thunder is appointed to awaken those who either abuse or disregard his Blessings, and to bring them to a Sense of their Dependence on him, and Duty to him; and if it does not consume them, it will at least alarm and admonish them. Thus does every thing about us serve to put us in Mind of our Creator, and is either the Effect of his Goodness to invite us to love him, or an Instance of his Power to make us fear him.

But neither are Storms only designed as a Lesson of Instruction to us, seeing they do of themselves produce very useful Effects, by cleansing and purging the Air of any Impurities or unwholesome Vapours that too long a Stagnation might occasion; by destroying those Swarms of Insects which though useful in some respects, yet would prove prejudicial to Mankind, if suffered to multiply in too great Abundance; and by replenishing the Cisterns and Reservoirs of those Countries which are destitute of Fountains, oftentimes swelling our Rivers more in one Hour, than the ordinary Supplies of Rain do in several Months in the Winter.

The same Causes that produce the Evaporation of the Waters, and all those Meteors that roll over our Heads, do also produce other Earthquakes. Effects no less dreadful under our Feet; I mean Earthquakes, and the Eruption of Volcano's. As the Agency therefore of the same Water and Air, is equally necessary both in the one and the other of these Productions, they naturally fall under the same Subject of Discourse.

The Vapours being condensed and falling down in Rain on the Surface of the Earth, mix with the Saltpetre which the Air has there deposited, the different Salts with which the Bodies of Animals abound, Oil, Dung, Sweepings, and many different Compositions, which soak with the Water into the Earth through ten thousand different Drains and Fissures, sometimes steering their

their Course over Strata of Salt, sometimes over Beds of Sulphur, at one time passing through Mines of Iron, at another through Layers of Vitriol, dissolving and carrying away Part of these Bodies as they pass along. These subterraneous Rivers, the Existence of which we before demonstrated *, cast up on the Sides of their Channels greater or smaller Quantities of these inflammable Materials, which dry and incrustate in Layers one upon another, as the Water lessens and falls away. The Composition being thus formed, the least Particle of Fire (brought thither by the Wind, or kindled by any other means, whether by Fermentation, which is very common betwixt sulphurous and mineral Bodies, or by some Mass of burning Sulphur in the subterraneous Caverns) inflames those Particles of Oil which are contiguous to it, and those communicate it from one Train of Sulphur to another. The Combustion being thus begun, the mineral Particles dissolve, the Air conveyed under Ground in its Vehicle of Water is dilated, and violently repels the Salt-petre, which is the most forcible and powerful of all the combustible Ingredients. Thus the Rarefaction of the Air, and the Projection of those Salts with which it is impregnated, conspire to act with such amazing Vehemence and Fury, that where-ever they meet with any Resistance to obstruct their Passage, they make the very Earth to shake and tremble from the Centre to the Surface, overthrow whole Towns, and would lay in Ruin whole Kingdoms, had not Providence, which weighs both the Usefulness and dangerous Effects of these tremendous Forces, set Bounds to their Power, by opening at proper

The Benefit of
Volcano's.

Distances certain Volcano's, or Vent-Holes, through which the imprisoned Air and all those combustible Ingredients that kindle so dreadful a War in the Bowels of the Earth may discharge their Fury, and by being dispersed in the open Air lose that Strength, which, when united and collected in one Body, acts with such irresistible Force on every thing that opposes its way. So that we may see how these Volcano's, which are looked upon as so many Plagues and Calamities in those Countries where

* See Dialogue XXI.

they are, are appointed by God for their Safety and Preservation.

After having traced the Origin of Meteors and subterraneous Fires, let us bestow a little Time in considering that of the Winds, on whose various Laws and Motions are founded the Arts of Navigation and Agriculture, and the Temperature of every Climate. Now of Winds some are regular, and others irregular: The former are those that blow constantly in some Countries and in some particular Latitude at certain Seasons: The latter are those which have no fixed Course or Rule that we know of.

The most regular Winds that we have any Knowledge of are those which blow almost all the Year betwixt the Tropicks from *East* to *West*, and those which we call the *Etesian* or annual Winds, which blow from the *North* to the *Equator* in our Summer, and from the *South Pole* to the *Equator* in our Winter.

Daily Observation of what passes in almost every Country a little before Sun-rise, will help us to a Solution of these regular Winds. When at the Break of Day there happens to be no settled Wind, we generally perceive at the time of the Sun's Approach to our Horizon, and a little after it is risen, a pretty brisk easterly Gale, which probably proceeds from the Eastern Air being dilated by the Return of the Sun, and driving before it that which is more dense and farther from the Sun; which necessarily causes an easterly Wind, which ceases as the Sun advances to our Meridian, and heats our Air.

By Parity of Reason, the same Wind must always precede the Sun in the Torrid Zone, and blow stronger there than in our Climates where the Influence of the Sun is more moderate. Accordingly they have almost always in the Torrid Zone a Wind blowing from *East* to *West*, and very seldom a westerly Wind; it being unnatural to suppose that the Sun can rarefy the Air in the opposite Horizon which it has left, especially after having rarefied it a whole Day; consequently it must dilate and give an elastick Spring to the Air of those Regions it is entering

into, and which had been condensed during the Space of one Night of twelve Hours.

The Trade-
Winds.

But in as much as the Sun passes by Degrees from one Tropick to the other, when it advances towards the *North*, the Northern Air being acted on by the Heat endeavours to expand itself; but being opposed by the Body of condensed Air which is still more Northern, it must consequently be reflected back to the *Æquator*, from which Quarter it finds the least Resistance.

The Direction of the Wind must therefore be from the *East* in Summer *, and from the *North* to the *South*; it must blow from the first, because the Sun first rarefies the Air in the *East*, after being condensed by the nocturnal Cold; and it must blow from the *North* to the *South*, because the rarefied Air is reflected back from the *North* to the *South* by the Resistance it meets with from the denser Northern Air. Hence proceed the Trade or annual Winds, which bring with them those vast Quantities of Rain that prove so serviceable and refreshing to the Inhabitants of the Torrid Zone that live on this Side of the *Æquator*. By the same Reason, when the Sun passes the *Æquinoctial* Line, and advances towards the Tropick of *Capricorn*, the Trade-Winds do necessarily blow from the *South* Pole, and cool the Inhabitants of the Torrid Zone that live on the other Side of the *Æquator* with welcome Showers.

The Course of these general Winds may indeed be interrupted or changed by the Resistance of Mountains, or some particular Winds blowing from a different or contrary Quarter; but these little Deviations from the general Rule and Course which they observe, are not to be deemed Irregularities, seeing they may proceed from a regular uniform Cause which we are ignorant of; and therefore we ought not to call that a Blemish in Nature, which only seems such through a Defect in our Understandings.

* That is, blow Easterly betwixt the *Æquator* and the Northern Tropick, while the Sun is on our Side of the *Æquator*.

Those Winds which we call local and irregular, derive the Origin and Cause of their Variations from Streams of Air rarefied under Ground; from the Bursting or Falling of Clouds, and the Eruption of the Air contained in them; from different Degrees of Heat and Cold, causing a proportionable Rarefaction or Condensation of the Air; from the various Determinations of the Air as it may be reflected from Mountains, or be interrupted by the irregular Windings and Breaks of the Sea-Coasts; and, in short, to a vast Variety of Causes that may conspire to give a different Modification or Direction to the Course of it. And the Multitude of these is so very great, that we can scarce hope ever to be able, by our most diligent Researches and Inquiries, to come to any certain or very useful Knowledge of them; however we cannot but acknowledge ourselves indebted to the good Will and patient Endeavours of some learned Men of the North *, who have been at the Pains to keep a faithful Register of the most minute Variations of the Wind for thirty Years successively. Repeated Observations of this kind may possibly help us to a general History of the Winds, and prove a sort of a Directory as to the Use that may be made of them. Notwithstanding the Inconstancy and Irregularity of these Variations in the Course of the Air, yet they are not without their very beneficial Effects, as we shall proceed to shew.

Local and irregular Winds.

After long continued Seasons of sultry Heat, when the Cattle begin to grow faint and weak, and the Verdure of the Fields to wither, the Sea oft-times very opportunely sends a *West* Wind with seasonable Succours of Refreshment: But as too long a Continuance of this moist Wind would prove hurtful to the Inhabitants and Fruits of the Earth, it is generally so ordered by the Course of Nature, that it should be driven back by an *East*-Wind, which, winging its way along the Continent from *Asia* into *Europe*, brings us fair and dry Weather. The *North* Wind comes armed

The Benefit of Winds.

The West Wind.

The East Wind.

* Mr. Clarke of Norfolk.

The North
Wind.

with Millions of frozen Particles of Air to precipitate, disperse, or condense the malignant and unwholsome Vapours of Autumn; it contributes more than any other Wind to fertilize and enrich the Soil, either by bringing with it greater Quantities of Salts, or by causing a less Diffipation of those it meets with in our Climate, rather accumulating and keeping them together, as the Wind that blows into the Mouth of a River raises and heaps up the Water without making any Addition to the Quantity of it. Lastly, the sharp Edge of the North Wind is taken off by that genial Warmth which the South Wind diffuses through the Air, kindling fresh Life and Vigour in every Part of Nature. These perpetual Vicissitudes serve to vary the Dispositions and

The South
Wind.

Productions of the Earth; they correct or prevent those ill Consequences which would necessarily result from any one fixed and permanent State of Things, and purify the Air by keeping it in constant Motion. Without the Assistance of these Winds we should be poisoned in our very Houses, and *Paris* and *London* would in a little time be no better than two great Sinks of Corruption.

The Winds then, we see, are the common Servants of Mankind; which are not only commissioned to warm and cool us by turns, but also to keep our Habitations clean and wholsome; which Office they perform with all imaginable Decency, carrying away invisibly every thing that might infect and corrupt the Air. But we are like those fantastical and dissatisfied Masters, who always overlook the good Qualities of their Servants, and are blind to every thing but their Faults. In like manner we perhaps scarce ever attend to the constant Services and good Offices which we receive from the Winds, but are perpetually complaining of every little Blast that proves offensive to our squeamish Humours.

Let us now briefly recapitulate the Effects of the Air above-mentioned: Vapours, Fogs, Clouds, Dews, Rains, Hail, Snow, Lightning, Thunder, Earthquakes, subterraneous Fires, Storms, regular and irregular Winds, all these great Phenomena owe their Original to the Elasticity of the Air, according as it is differently condensed

or dilated by the different Causes that act upon it. A few cubick Feet of Air rarefied by Fire in a little Mine are sufficient to blow up a Bastion with the Battalions that are upon it. The famous Cities of *Nice*, *Hercolane*, *Antioch*, and *Palermo*, were almost intirely swallowed up by the Eruption of a Body of Air impelled upwards by subterraneous Fires: Nay, a few Inches of this Element, and Salt-petre, proved to be of sufficient Force to wing those fatal Balls that took off the two famous Marshals, *Berwick* and *Turenne*. Now how wonderful must the Mechanism and Structure of that Spring of the Air needs be, which, under the Finger of God, can prove an Instrument sufficient to bring about the most extraordinary Revolutions in Nature and human Society!

The same Spring or Elasticity of the Air is, in Plants and Animals, the Principle of their Vegetation and Growth. For that the Air does enter into the

The Vegetation
of Plants.

Composition of Plants is incontestable, whether by insinuating itself into their Bodies through those hollow Tubes, which the famous *Malpighi*, by the Assistance of his Microscopes, discovered in them, and which he therefore calls Trachian Arteries, or Lung-Pipes [*Spiracula*]; or whether it finds Admittance through the Pores of the Earth, or through those of the Bark and Leaves of them; or lastly, whether the Water serves as a Vehicle to convey it into the Substance of Vegetables, seeing this Element has always more or less Air in it, and derives its Fluidity from it. By which soever of these ways it comes to pass, the Air having gained Admittance into the Bodies of Plants, it there remains inactive, while chilled and compressed by the Winter's Cold; but being revived by the genial Warmth of the returning Spring, it exerts its elastick Powers, communicating Vigour and Motion to the Salts and Juices. But as excessive Cold does freeze and bind up its active Powers, so extreme Heat is no less an Enemy to it; for being thereby overmuch relaxed and rarefied, it loses its Spring and Force, and the Plant must necessarily languish and die, unless some kind refreshing Shower comes to its Relief with a fresh Supply of nutritive Juices, bringing with it likewise a new Recruit of more compacted Air, which by
its

its elastick Force may cause the Sap to ascend, and distribute Nourishment to every Part of the Plant.

The Respiration
and Nutrition of
Animals.

At the first View one would be apt to imagine that the internal Heat which is in the Bodies of all Animals was sufficient to separate the Chyle from the grosser Parts of their Food, and to distribute the Blood and Juices in proper Quantities all over the Body; whereas this Heat only acts by the Mediation of the Air, which is of so necessary an Use to it, that without the Instrumentality of the Air the Fire would not be able to act at all; accordingly we find, that when the former is evacuated by any means, the latter loses its Power. This may be illustrated by a familiar Instance: The Hand has in itself the Principle of Motion; but when it would make an Impression on any hard Body, or drive a Nail, it borrows the Assistance of a Hammer: Now the Hammer has no Motion but what it receives from the Hand, and yet the Hand would not be able of itself to drive the Nail: In like manner, the Fire in the Bodies of Animals is, together with the *Æther* that is intermixed with it, that first Principle of Motion which separates the nutritious Juices from the coarser Part of the Food, concocting them in the Stomach, mixing them with the Blood, and compacting the whole Frame of the human System by the Distribution of Salts, which like so many small Nails keep all the Parts together: But the Fire does not produce the Effects immediately and of itself, but by the Agency of the Air, which it dilates, thereby causing it to perform the Office of a Hammer, to give a greater Force to its Strokes; or if the Air does not act by Percussion, it does at least by Protrusion, when being rarefied and dilated by the expansive Power of the Fire, it fills a greater Space than before, and consequently drives before it those Bodies which obstruct its Enlargement, thereby communicating that proper Degree of Motion to all the Fluids, Muscles, and Vessels of the Body, as is necessary for the Discharge of their several Functions.

The Lungs, which are the Organs of Respiration, are contrived in the most artful manner, to procure to the Body all those Benefits which can possibly arise to it, from the most exact Proportion of the Pressure and Elasticity

of the Air to its several Occasions, being formed 'so as to distend themselves in order to draw in a fresh Quantity of Air, and to contract when they want to breathe out that which has done its Office. By this constant Act of Respiration we expel the rarefied Air, after it has contributed its due Proportion of Motion to the Intestines, the Chyle, and the Blood, and can be of no Service any longer, and immediately inspire a fresh Recruit of more dense Air to succeed it in the same Operation; and if at any time, through any Disorder or Weakness of the Body, the excessive Heat of the Season, or of that particular Place we are in, the Air we breathe is so much rarefied as to lose that Force and Elasticity which is necessary to assist the peristaltick Motion and the Circulation of the Blood; in this case we are obliged to have recourse to cooling Draughts, cold Baths, and even Ice itself, to the end that by these means we may restore the Spring of the Air, and give it that active Force by which it performs the Offices of Digestion and Nutrition in our Bodies. We shall not inroach on the Province of the Anatomists, so far as to undertake to explain the particular Structure of the Lungs, the Action of the Stomach, the Contraction and Dilatation of the Heart, the Communication betwixt the Arteries and the Veins, the Distribution of the Blood, and the Perspiration of the superfluous Juices and Humours: It is sufficient for our Purpose to have accounted for all these surprizing Operations from that single Property of the Air, its Elasticity.

The wonderful Phenomenon of Respiration naturally leads us to the Consideration of another no less surprizing, and inseparable from it, and which, though universally the same throughout all Nature, is no where more conspicuous than in the human Body; and this is that Counterbalance which is betwixt the Pressure of a large Body of Air, and the Elasticity or Resistance of a very small Quantity of the same Element. This will be best illustrated by an Example: Take a flat empty Bottle, and lay it upon its Side; now at first, one would be apt to imagine, that the Pressure of the Air on the external Surface of the Bottle, and which is equivalent to the Weight of thirty-

The Counterbalance betwixt the Pressure and Elasticity of the Air.

thirty-two Feet of Water, every Foot weighing several Pounds, should crush the Sides of the Bottle together. And this would be the Consequence, were it not that the Air contained within the Bottle, whether it be stopped up or not, does by a contrary Pressure from within, counter-balance the external Pressure, and thereby keep the Bottle from breaking. And that this is the Case, will appear from applying a Syringe to the Mouth of the Bottle, and pumping out that internal Air, which did by its Renitency sustain the Sides of it; which is no sooner done, than the external Air acting with its full Force of Gravity on the Surface of the Glass, and meeting with no Opposition from within, immediately breaks the Bottle. It has not the same Effect on a round Bottle, the Structure of it being like that of a Vault, the several Parts of which mutually sustain each other, and the Pressure of the Air in the same equal Manner, as the Arches of the *Pont au Change* support the prodigious Weight of those two Rows of Houses that are built along the Sides of it.

The Body of a Man being rather flat than round, one would think that the Weight of those two Columns of Air that press on his Stomach and his Back should squeeze both Sides together, seeing the lateral Pressure of Fluids is equal to their perpendicular Pressure; which is the Reason why any Liquor will run out of a Cask, through a Hole made in the Side of it, as fast as through one made at the Bottom. In like manner the Column of Air which presses on our Stomachs, acts as forcibly as that which presses on our Shoulders. We before observed, that a Column of Air, which sustains in a Tube twenty-eight Inches of Quick-silver, or thirty-two Feet of Water, is equivalent to these two Weights singly, and that the Base of the sustaining must be equal to that of the sustained Column; for Example, a Column of Air, that sustains a Body of Water thirty-two Feet high, and one Foot square, must necessarily be one Foot square itself. Now as we can determine the Weight of a Column of Water one Foot square, so can we also that of a Column of Air of the same Dimensions. A cubick Foot of Water weighs about seventy Pounds; consequently a Column of Air one Foot square that sustains thirty-two cubick Feet of Water, must weigh thirty-two times seventy, or two thousand two hundred

hundred and forty Pounds ; say only two thousand one hundred Pounds, which is the least it weighs, and reduces it to the Weight of only thirty cubick Feet of Water. Every Man, generally speaking, is above five Foot high and one Foot broad ; we will content ourselves with the Allowance of five Feet, and set aside the Thickness of the Head, the Shoulders, and the Sides, to discount for the lesser Surface of the Legs : Thus then supposing him to consist but of two Surfaces, each five Feet square, the Pressure of Air upon the whole Man will be that of ten Columns of Air, each Column one Foot square, and weighing two thousand one hundred Pounds, and consequently the Sum total of Weights will be twenty-one thousand Pounds. We do therefore, according to this moderate Calculation, sustain on our Bodies the Weight of twenty-one thousand Pounds of Air. How surprizing that we are not crushed to Death by such an enormous Weight ! What dreadful Apprehensions is not this Consideration capable of alarming us with ! But how do all our Fears vanish, or rather are changed into Admiration, when we come to understand how that little Quantity of Air that is within us, and which we are continually breathing in and out, is able by its own Elasticity to counterbalance the vast Pressure of the external Air ! These two contrary Forces reciprocally destroy each other, or rather, though they both really act, are not felt by us, because they equiponderate. Now if this Equality of Pressure be destroyed, either by extracting the Air that is in the Body of the Animal, or by exhausting the circumambient Air, which may be effected by the Assistance of a Pneumatick Engine ; in the former Case the external Air will squeeze the Animal flat, and press him to Death ; in the latter, the internal Air will dilate itself to that Degree, as to make him swell till he burst.

If the Elasticity or Spring of that little Quantity of Air that is contained within our Bodies is able to suspend and counterbalance a Weight exceeding twenty-one thousand Pounds, it must necessarily act with a Force equal to that Weight. When we think of this, how amazing must appear the Mechanism of the Air, in which the great Artificer and Creator of it has united two such opposite Forces !

Forces! The same Air that by its external Pressure on our Bodies continually threatens our Destruction by crushing us to Atoms, does at the same time make as great an Effort within us to rend our whole Frame asunder: Our only Security consists in the Equality of these two formidable contending Powers, the same Hand which formed them to put in Motion the whole System of Nature, having balanced and tempered them in such exact Proportion, as that the Violence of the one should be repelled by the Activity of the other.

Those that are well skilled in Mechanicks know how to manage these Forces with a surprizing deal of Art, and to augment the one by diminishing the other: They can exhaust the internal Air to give full and free Power to the Pressure of the external; an Example of which we have in the Ascent of Water in our Pumps, which immediately follows the Sucker upon its taking off the Pressure of the superincumbent Air: Or they can overcome the Pressure by increasing the Spring of the Air, by applying to it a more intense Fire than that which rarefies the Air in our Bodies: Such is that surprizing Augmentation of the Air's Elasticity in Gun-Powder, when it is put in Motion by the Fire that is in the Sulphur, and darts with great Vehemence those hard, sharp-pointed Particles, of which the Salt-petre is composed.

But however curious those Discoveries are which have taught Men the Use of these active Powers of the Air, let us not yet take our Leave of the simple Workmanship of Nature, but proceed to consider those other still more surprizing Effects, which result from the Structure and Formation of the Air.

Now the Air informs us, with no less Fidelity than Expedition, and from every Quarter, of every thing that can any ways concern us, whether good or bad.

Smells.

And, first, it is the Vehicle of Smells, by transmitting which to us it informs us of the good or bad Qualities of our Victuals; on the one hand, acquainting us with what is good and wholesome, by those agreeable Sensations which it conveys to us; and on the other, by making offensive Impressions

Impressions on our Senses, it gives us timely Notice to beware of every thing that may be poisonous, infectious, or unwholesome, whether in our Meat, in the Air, or our Habitations.

Secondly, If the Air discharges the Part of a faithful Monitor, by the different Informations it sends us by the Ministration of Smells; it performs the same Office as less diligently, and more effectually, by that Intelligence it conveys to our Ears by the Mediation of Sounds, which we may consider as so many Couriers which it dispatches to us every Moment, to bring us News of what passes oftentimes at a very considerable Distance from us. It is our Business to make a proper Use of such seasonable Advices.

Sounds.

The Nature of Sound has very much exercised the Curiosity of Philosophers; yet after all their Study and Labour, your very Mechanicks and Musicians, who have attained to the Art of swelling, softening, and variously modulating Sounds, give us better Satisfaction than all the Attempts of Philosophers to explain the Formation of them. Were the internal constituent Parts of all sonorous Bodies, whether of Wood, Metal, or any other Materials, formed in the Shape of a Chord, a Gun-worm, or a wreathed Column, we might then probably give some tolerable Account of their Sound from the Vibration of their Parts: We might then say of these Bodies, that they are compressed or dilated, are in a State of Tension or Relaxation, that they act upon the Air, which reverberating on them causes a Vibration in their Parts, which decreases or ceases according to the Resistance communicated through the Air from other Bodies, or from that of the Air itself. But laying aside all fruitless Inquiries how these Motions in Bodies, and these Undulations in the Air, which are the Cause of Sounds, are performed, let us rest satisfied with knowing that this particular Organization of the Air is a Property implanted in it by God, in order to communicate to us such Notices as are of use to us, where the same Information cannot be had from the Sight. For Example; my Mind is employed in contemplating those numberless Lessons of Caution and Instruction, displayed in the Formation and

Com-

Composition of those Elements which God has been pleased to create for my Use ; I set my Thoughts to work, and form divers Judgments thereupon ; I find that he has made me capable of discerning clearly their Beauty and beneficial Properties, to the end that I may be supplied with those Things I want, and be grateful for them ; but I find also, that he has with-held from me the Power of coming to the thorough Comprehension of their respective Natures and Essences, lest I should be too much exalted with the Conceit of my own Wisdom, or be so much taken up in the Pursuit of Knowledge, as to be diverted from paying my Duties to him, and acknowledging my Dependence on him. These, suppose, are the Reflections I make within myself, and as my Thoughts are invisible, they can only be known to me ; how then shall I be able to communicate them to the Company I have the Honour to be with ? By the Motions of my Tongue and Lips I

Speech. find myself able to form such different articulate Sounds as are agreed on by the general Consent of Mankind to be the

Signs of such and such Ideas : By this means therefore, those who hear the Sounds which are fashioned in the Air by the Motion of my Lips, become informed of those Ideas of which they are the Representatives, and consequently become acquainted with my Thoughts and Sentiments. Hence it appears, that the Air is the common Interpreter of all Mankind, and that Channel of Communication in which the most retired Secrets of our Hearts are conveyed to each other.

Nor does it only mutually communicate Intelligence to Persons that are within the Circle of Conversation, but even to such as are at a very great Distance from one another : For Example ; those who live within a City cannot see what passes without the Walls that inclose them, nor can they who see the Enemy making an Attack at one Gate spread the Alarm immediately to those who are at the other Extremity of the Town, to give Notice of their Danger, by the sole Stretch of the Voice ; but the Centinel who from off the Walls spies the Enemy approaching at a Distance, gives the Signal by striking on a Bell, the Sound of which is carried by the Air in a Second of Time, that is to say, the sixtieth Part of a Minute,

Minute, one thousand and eighty Feet, or a hundred and eighty Toises all round the Watch Tower; in another Second the Sound is propagated other eighty Toises, and so on. By these means the whole Town is alarmed in less than half a Quarter of a Minute, which gives them an Opportunity to run to their Arms, and repulse the Enemy.

Thus we see that the Air is the most expeditious Messenger we can employ. But neither is it (to our great Surprize) less faithful in delivering its Message, than it is speedy in conveying it. It distributes the Harmony of a Concert to the Audience all around with the utmost Exactness, it keeps true Time, runs over the nimble Divisions, repeats the least Inflections of the Voice, and does not lose so much as a Quarter of a Note, or the least Variation of a Tone. In a word, it runs through all the Parts of Musick, and catches every Air and Grace that embellishes Harmony; it swells the manly Sound, and thunders in the Note, or faintly flutters in soft dying Strains; it then again revives, and with bold Touches kindles into Rage, or gently soothes with pleasing Melody. Thus does it rouse or calm the Passions with sympathetick Sounds, and tunes our Affections with most persuasive Eloquence.

From the wonderful Effects of Sounds, which are form'd and propagated by the easy Motion of the Air, let us pass on to that amazing Phenomenon the Light, of which it is also the ordinary Vehicle. And here the first

The Air, why
invisible.

Subject of Astonishment that presents itself to us is, that a Fluid so nearly related to us as the Air is, and which never ceases to act upon us, should at the same time be invisible to us; and yet this is nothing less than an Effect of God's good Providence, and watchful Care over us, in order to gratify us with a Prospect of all the Works of Nature; for were the Air visible, we should no longer have a distinct View of any other Objects; for every Particle of the Air having a Surface sufficient to reflect the Light, we should see all the Bodies that surround us, as through those Rays of the Sun that pass through a *Camera obscura*, and which are reflected to our Eyes from those little Atoms of Dust that float about in the Air: Whereas, by making the Air invisible, God has not only given us a more distinct Survey of his Works, but has also concealed

from

from us the Sight of what it is for our Ease and Happiness not to see. Were the Air discernible like other Bodies, the Vapours would be still more so, the least Smoak would disfigure the beautiful Landskip of Nature. Life itself would become painful and uneasy, we should see the Humours that are perpetually sent out by Perspiration from the Bodies of Animals, all the unctuous Vapours, all the Filth and Nastiness that exhales from our Kitchens, our Streets, and common Sewers; Society would be rendered insupportable, and we should seek for Health and Safety in Solitudes, flying to Woods and Defarts to escape the Dangers that seem to threaten us, or to get out of the way of those Nuisances, which would be the inevitable Consequences of such a Sight. But nevertheless, lest those Exhalations, which cease to be offensive or hurtful to us when disperfed, should, by being invifible, infenfibly gather and thicken fo as to fuffocate or injure us, God has not only freed us from thefe perpetual Apprehenfions, but alfo forewarned us of our Danger by the Senfe of Smelling, and refcued us from it by the Current of the Winds.

But however fine and delicate that Structure of the Air is, which renders it invifible to us, yet it is not without a Degree of Force, fufficient to refract and inflect thofe Rays of Light which enter fide ways into it; from which Property of the Air, very great Advantages accrue to Mankind.

Now, in order to underftand the Effects of Refraction, let us divide the Circumference of the Globe of the Earth into 360 Degrees or equal Parts; the Half of which is 180: Let us now fuppofe ourfelves placed in the middle of this Half, fo as to be able to fee 90 Degrees, or one fourth Part, of the Heavens on one Side, and as much on the other Side. Now it is certain, that we then only begin to fee the Sun, when it leaves the inferior Half or Hemisphere; which is invifible to us, and enters upon the Confines of that Half of the Heavens which constitutes our Hemisphere: In like manner, when he has run his Courfe through our Horizon, we lofe Sight of him the Moment he paffes into that which is beneath us; and confequently as his Rays do then ceafe to come directly from him to us, fhooting up obliquely into the

The Air the
Cause of the Re-
fraction of Light.

the Atmosphere on one Side of us, it should happen that the Moment he sets beneath our Horizon, we should instantly be deprived of the Benefit of Light, and be totally involved in Darknefs: But this, we find, is not the Case; for we enjoy Day-Light a full Hour, oftentimes much longer, after the Sun is set, and as much Twilight before the Sun is risen above our Horizon. The Advantages we receive from this Increase of Day, depend

upon the particular Structure of that Body of Air, which God has diffused round the Earth, the exact Altitude of which

The Benefit of the Crepuscles.

he alone can measure, though we are sure it is at least several Leagues high. He hath established so exact a Law of Proportion betwixt the Air and the Light that passes through it, that when the Motion of the latter is perpendicular to the Earth, it holds on its Course in the same Line of Direction, without the least Deviation; whereas a Ray of Light entering the Atmosphere, either in an horizontal or oblique Direction, instead of pursuing the same Course, and passing directly through the Atmosphere, it is refracted down to the Earth, by which Bending or Inflection of the Rays, its Inhabitants enjoy the Benefit of that Light, which, were there no such Medium to alter its Direction, would be of no Use to them. Thus, when the Sun approaches to our Horizon, ere it becomes visible to us, it projects into the Atmosphere, which environs the Earth, several Rays, which passing on in strait Lines through the Atmosphere, would not be discerned by us; but meeting with a Body of Air, which has the Power of refracting or bending them down to us, we have Day before the great Fountain of Light, the Sun, appears, and some time after it has taken its Leave of us. When the Sun comes to be 18 Degrees below our Horizon, its Rays are no longer refracted down to us by the Atmosphere; total Darknefs does then ensue, and gives the Signal for Man to cease from his Labour, and repair to Rest; and if the Moon and Stars do then hold forth their Lights, to mitigate the Horror of the Night, yet they shine with so gentle and mild a Splendor, as not to disturb his Repose. Thus we see how this Law of the Refraction of Light is calculated, by the infinite Wisdom and Goodness of God, to be of universal Benefit to Mankind,

kind, who thereby gain at least two Hours of Light every Day, but more particularly to those who inhabit the Frozen Zones; who, but for the Benefit of the Crepuscles, would be involved, for several Months together, in one continued Night.

The *Northern*
Light.

This auxiliary Light, which is refracted by the Atmosphere, in the Night-time, towards both the Poles, does oftentimes meet in its Passage thither with a very dense Air, thick Clouds or Collections of Snow in the upper Regions of the Atmosphere, from which it is reflected in different Directions, according to the different Inclination of their Surfaces. Hence probably come those Streamers, which Philosophers call *Aurora Boreales* *, or *Northern Lights*, and which fill the Minds of the common People so often with terrible Apprehensions of some direful Events, of which these seem to them so many Prognosticks, though in Reality they have been a common Phenomenon in all Ages. These Lights are no less frequent in the *South*, than in the *North*; the Reason of their appearing to us in this Quarter, more commonly than the other, being the vast Distance we are at from the *South Pole*, which hinders the Light reflected thence from coming to us, it neither being reflected nor refracted, any farther than is necessary for our Occasions.

Other Uses of
Refraction.

Nor is it the only Benefit we reap from the Laws of Refraction, that the Day is thereby protracted for our Use, even after the Sun has finished his Course from one End of the Horizon to the other; for if after the pitchy Darkness of the Night, the Day were to break in suddenly upon us, in the first Strength and Power of its Brightness, the tender Organs of Sight would not be able to endure such excessive Splendor, but be overpowered by the Violence of the Shock; whereas a gradual Increase of Light does insensibly strengthen the Opticks, and prepare them for the Reception of a greater Degree of Lustre; the Twilight inures them to bear the Morning-Sun, and this again fortifies them against the more powerful Beams of it, when shining in its full meridian Glory. Thus has

* See the History of Gregory de Tours, who was an Eye-witness of the *Northern Lights* in the VIth Century. He died in 591.

Providence, in tender Compassion to our Weakness and Infirmities, used all possible Precautions that might any ways contribute to our Security or Defence.

After this short Survey of only a small Part of that wonderful Counsel and Design, that appears in the Structure and Formation of the Air, and of that surprizing Agreement, established in the most exact Proportion betwixt the Air and the Light: Let us bestow a Minute's Reflexion on the Nature of the latter. And here we may observe, how great a Scope for Inquiry and Debate that single Body yields, to which all other Bodies owe their Beauty, and the Variety of their Colours! And first it may be made a Question, Whether Light be a Body or no; whether it is the Fire itself, or only an Accident of Fire; whether it proceeds from the Sun, as from an inexhaustible Fountain of Light, which is continually emitting it from its own Body, without suffering any Decay or Diminution itself? Or whether it be independent of the Sun as to its Essence, being at all times, in the Night as well as in the Day, equally diffused round about us, and ready to make itself visible to us, when the Fire of the Sun shall put it into a proper State of Motion, and thereby cause it to be reflected from the Surfaces of other Bodies to our Eyes? Farther it may be asked, by what inconceivable Degree of Force the Sun can project Rays of Light from its own Body to us, in less than seven Minutes * time, through a Space which a Cannon-Ball would require several Years to perform, though moving all the time with its greatest Velocity? Or to what miraculous Cause shall it be ascribed, that if we suppose numberless Millions of Mirrors, or Looking-Glasses, placed at any Distance from the Earth, there should proceed from all the Points of the terrestrial Horizon, a sufficient Number of Rays, to reflect the Image of the whole Horizon in the most distinct manner, from every particular Mirror? Again, how shall we be able to account for that other most amazing Phenomenon, that if we suppose as many Spectators as we before supposed Mirrors, every Spectator shall be able to perceive distinctly the Image reflected from as many Mirrors as he can see, while the same Representations are multiplied in such a manner, as to be discerned by ten

* Newton's Opticks.

thousand other Spectators at the same time, without any Confusion? Now how shall we account for all these Pencils of Rays, crossing each other oftentimes in the very same Point, meeting in so many Focus's, reflected and refracted so many ways, and yet painting the Object in the Eye, with the greatest Accuracy and Proportion? All these Mirrors, and all these Eyes, have indeed only an imaginary Existence; but were it possible for them to be really placed in the manner we have been supposing, these Effects would immediately follow, without any Alteration being caused in the Air; the Rays which would produce these Wonders, do every Instant proceed from their Objects, and would be perceived distinctly in all Directions, were there a sufficient Number of Eyes to behold them.

But we need not take in the whole Horizon, seeing the Light that is reflected from any one single Point of it, will afford sufficient Matter of Admiration and Astonishment; for take which we please, it is certain that

Colours. Newton's Opticks.

there do fall upon that, as well as upon all other imaginable Points, seven Rays of so many different Tinctures or Configurations, and which have the Power of exciting in us the Sensations of seven different Colours, a Red, Orange-Colour, Yellow, Green, Blue, Indigo, and Violet: This is the Order, in which a single Ray of Light, transmitted through a Prism, distributes its different Colours on a Piece of Paper; for every Ray of Light does really consist of seven other lesser Rays or Lines distinct from each other, and which become visibly so when separated, by passing through a Prism: Now if the Point on which a Ray of Light falls, is disposed by the Nature of its Surface, to reflect but one of those seven lesser Rays, it will then appear to be of the same Colour with that particular Ray which is reflected from it; if it reflects more than one, it is then of a mixed Colour, as Cammon-Colour, Gridelin, Slate, Olive-Colour, &c. if it reflects none of these Rays, or scarce reflects them at all, it is then black, or inclining to black, according as they are more or less absorbed; if it reflects all the different Rays, it will appear white. Thus will this little Point absorb or reflect the different Rays of Light, according

it is disposed to do the one or the other, from the Nature of its Surface, and the Texture of its Parts.

Nor is the Structure of those Rays which strike upon every Object, and are directed to every Part of Space at the same time, more wonderful and surprizing than the Manner in which they are reflected, so as to paint on the Retina, or optick Nerve, the distinct Image of each particular Object, after having been refracted and collected by the different Humours of the Eye. Reason is lost in the Contemplation of this natural Mystery, and we must confess, with all possible Submission of our Understanding, that both the Work and the great Artificer are incomprehensible by us.

False and deceitful then are those Hopes which Philosophy gives us, of ever attaining to a perfect Knowledge of the Essence and Composition of these Elements. We have just now made it evidently appear from the Consideration of some Effects, that every Particle of Air is of itself a little Spring-Machine, contrived with wonderful Art and Skill, to execute the Purpose it was designed for. How shall we have Patience after this, to listen to some Natural Philosophers *, who (vainly imagining that the shallow Line of human Understanding is sufficient to fathom all the Dephs of Nature) tell us, with a very grave Face, that we are only to look upon the Air as a huge collective Body, consisting of a vast Number of little Particles without any regular Shape or Form; or as a sort of Raspings filed off from the Corners of a vast Multitude of triangular or hexagonal Bodies, by rubbing one against another? Mr. *Des Cartes*, who was the Founder of this Hypothesis, was indeed a very great Geometrician, but there may be such things as geometrical Extravagancies and Chimera's; and of all philosophical Delusions, that of believing the Air, the Fire, the Light, and the whole System of Nature, to be the necessary, or even possible, Effect of Motion impressed on Matter, is the most dangerous and fatal; for however this Conceit may have gained ground with some Men of great Abilities, yet it certainly has a natural

* *The Principles of Des Cartes. Rohault's Physics, Part 3. Chap. 2.*

Tendency to make us ungrateful, by placing God at too great a Distance from us, and to lead us into Error, as being founded on absurd and irrational Principles. Let Matter be never so differently modified by Motion and Friction, yet nothing can result from these Causes but sluggish, inactive Masses of Matter without Beauty or Proportion, or by perpetual Friction it will be pulverized into Atoms. The Motion impressed on Matter is a blind, senseless, mechanick Power, incapable of itself to produce any one Instance of wise Design, Order, or Liberty; it is impossible for it to form an organized Body, or to give Being even to an Orange or a Cabbage. What but a Hand directed by Skill and Wisdom, could possibly contrive within the Rind of an Orange, those little convenient Apartments, to contain a Juice so delightful and refreshing to the thirsty Inhabitants of Sun-burnt Climes? What else could fold and fashion the lesser Leaves of a Cabbage, into that firm compacted Globe, and shelter them from the cold Air, and the Inclemency of the Weather, by a thick Covering of the larger Leaves, in order to make them more tender and delicious? Now if we can discover the Footsteps of Contrivance and Design in the Formation of an Orange; if God has not thought it derogatory to his Honour and Majesty to display his Wisdom and Power in the Creation of a Cabbage, by a particular Act of his Will, for the Service and Nourishment of Man, shall we deny that the Air, the Fire, the Light, and all those heavenly Bodies that move in such exact Order and Harmony round us, and for us, were created by so many special Acts of the Divine Appointment? No; nothing but the immediate Exercise of his Power and Wisdom could give that surprizing Force of Elasticity to the Air; nothing less than Omnipotence could multiply the Rays of Light *ad infinitum*, dividing every Ray into seven Lines or lesser Rays of different Colours; nothing but the same mighty Hand could form the Elements, allotting to each its proper Province and Powers, balancing those Powers in the most nice Proportion, and constituting that mutual Relation and Dependence betwixt one Element and another, so necessary to the Order and Harmony of the whole System.

Is Motion capable of mixing and uniting Elements of so contrary Natures as Fire, Air, and Water, in such exact Proportion as not to destroy each other; or of giving, as it were, Wings to the Air, or the Fire, to sustain the Water, and to keep it in a constant State of Motion and Fluidity? Is Motion capable of regulating the Quantity of Vapours and Rain in the Atmosphere, so as that they shall be just sufficient to water the Earth without causing an Inundation? Can it with Foresight and Design form the Hail of such a Size, as that it shall be big enough to destroy the Fruits of the Earth, and to punish the Wickedness or Ingratitude of its Inhabitants, and yet prevent its growing to be as big as Rocks or Mill-Stones, lest it should beat down the Trees, or dispeople the Earth? Or if Motion was sufficient at first to form the Air, and to temper the Spring of it; to produce the Fire, and endue it with that extreme Force; what other Power shall we call that which so often compresses and condenses the Air, restrains the Fury of Fire, keeps it locked up in a Piece of Sulphur, confines it Prisoner in Oil or Wood, and keeps it motionless and inactive in our Cellars and Storehouses, that it may be ready on all Occasions to be employed for our Use and Service?

Let us then conclude, that he alone who first created every Atom and Particle of Matter, of which the universal System of Nature is composed, was able to give to every Part that proper Form and Texture, as should best promote the Beauty and Usefulness of the whole Structure: Nay, so absurd is it to suppose that mere Motion is the efficient Cause of the regular Formation of each Element, that common Sense will tell us, that the Motion of all the Bodies in the Universe, and the Action and Operations of the Elements, are the natural Effects of that admirable Form and Fitness which God has bestowed on all the Parts of Matter, and of that Order and Harmony which he has established throughout the whole; as Motion impressed on a Mass of Iron, Copper, and other Materials, will never be able to produce Wheels, Springs, or any Machine; but Wheels and Springs being well made and skilfully put together, will produce just Movements, and a regular Machine. In a word, we can attain to a competent Knowledge of the Motions of the Air, the Fire,

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and the Light; we can make deep Researches by Study into the Properties of these Elements, and the Influences they have upon us, and thence learn how to employ them to our Use and Convenience; and thus far our Knowledge is commendable; but then here we ought to stop; for as to the particular Nature, Essence, and Structure of the Air, and the other Elements, he alone who made them can thoroughly comprehend them. It is for us therefore to praise his Goodness, and be thankful to him, who has created all these excellent things for our sakes, to make a proper Use of them, and to rest satisfied and contented with knowing so much of them as he has thought sufficient for us.

F O S S I L S *.

DIALOGUE XXIV.

The PRIOR and CHEVALIER.

Chevalier. **W**E begin to soar in our Speculations: We have quitted the Earth to take a Survey of what passes in the Regions of the Air: Pray, what hinders us from taking a higher Flight, and discoursing on the celestial Phænomena? Methinks I should take a great deal of Pleasure in making a Visit to the Sun. Will our Philosophy help us to an Acquaintance with the Nature and Operations of that bright Luminary?

* Whatever is, or may be dug out of the Earth, we call a Fossil.

Prior.

Prior. Permit me, my dear Chevalier, to clip the Wings of your Curiosity. I am indeed delighted to find you in such a Thirst after Knowledge, but let us not soar too high above the Earth, lest we meet with the Fate of *Icarus*; though the Story is fictitious, yet the Moral is instructive; besides, I do not know whether it be lawful to extend our Curiosity much farther. We all behold the Beauty of the Sun, Moon, and Stars, and enjoy all those Benefits that flow from their regular and constant Revolutions. You will ere long, probably, have an Opportunity of going through a Course of Astronomy, and get acquainted with the Motions of those heavenly Bodies, which divide the Life of Man into that agreeable Variety of Times and Seasons with which it is diversified; but as to the particular Nature and Structure of that glorious Luminary, which is, as it were, the very Life and Soul of Nature, it would be Presumption in me to undertake to give you a Description of it, who am not thoroughly acquainted with that of a Straw, that is blown about by the Wind. The Contemplation of the Heavens, and the heavenly Bodies, makes one great Part of the Happiness of our Lives; but the Nature of that innumerable Multitude of Lights, which, on account of their vast Distance from us, appear but as so many Spangles through our very best Telescopes; their Operations and Influences, their Use and Design; these are Discoveries, which, in all Likelihood, we must never expect to attain to in our present State; let us then return to the Earth, which is appointed to be the Place of our Abode; this was created for our Nourishment and Entertainment, and as we are to look upon it as our Estate and Possessions, it behoves us to inform ourselves of the real Worth and Value of it, to keep an Account of its various Productions, and to take a general Survey of it. Hitherto we have visited the most beautiful Apartments of this our great Habitation, and seen the chief Furniture that they are adorned with; from the upper Apartments let us descend into the Cellars, and such of them as are under Ground.

The Bowels of
the Earth.

There are several Sorts of Materials which are absolutely necessary to Man, in order to procure him a decent and commodious Habitation: Now it is certain that God might have placed all these Materials on the Surface of the Earth to be near at hand, and ready to be employed on all Occasions; but then the vast Quantity of them would have almost covered the Earth, whereas now our Land is happily disincumbered of all that troublesome Luggage, and the Surface of the Earth disengaged of those Embarrassments which would otherwise obstruct all Husbandry, and the free Passage of its Inhabitants. Metals, Stones, and a hundred other Materials which are constantly employed for our Use, and were designed to be a never-failing Treasure for the Service of all succeeding Ages, are carefully locked up in vast Storehouses under our Feet, where we are sure to find them in all Cases of Necessity; for Providence has so wisely ordered it, that they are not buried near the Centre of the Earth, nor yet at such a Depth as to make them inaccessible by us, but at such a proper Distance below the Surface, as that the Coat of Earth above them should have a sufficient Depth of Soil to produce Fruits for the Use of Man, and yet not to be of such a Thickness as to prevent his digging down into those subterraneous Magazines of Treasure, which are there deposited to supply his Wants and Occasions: By this Piece of natural Oeconomy we enjoy a double Advantage, and the same Spot of Ground yields us a two-fold Crop.

Chevalier. I find then you are here again of a different Opinion from my good Friends *Horace* and *Ovid*; though the Reason, I perceive, is because they are not always of the same Side with Reason and Truth: If I may take *Horace's* Word for it, Gold can no-where be better lodged than in the secret Bosom of the Earth *: Nay, he advised the *Romans* in good Earnest † to take their Gold

* ——— Sic melius fitum

Cùm Terra celat.

Carm. 3, Od. iii.

† ——— In Mare proximum

Gemmas, & Lapides, Aurum & inutile,

Summi Materiam Mali,

Mittamus.

Carm. 3. Od. xxiv.

and Jewels, and fling them all into the Sea, to remove from them, as he terms it, the Root of all Evil. And if we may believe *Ovid* *, it is a Crime for Man to ransack into the Bowels of the Earth, nothing less than Larceny to purloin those Riches which God on purpose removed out of our way, and concealed from our Sight in the dark Caverns of the Earth. I was indeed mightily taken with these Thoughts at first; but upon a nearer Examination I find neither Sense nor Reason in them, The Mischiefs that are occasioned by Gold and precious Stones, do not proceed from the Nature of the things themselves, but from our inordinate Pursuit after them, or Misapplication of them; for certain it is, that God would never have placed these things within our Reach, but to the end that they might be made serviceable to us.

Prior. Your poetical Gentlemen are oftentimes much addicted to affix a Mark of Guilt on Actions very innocent, and on the contrary, to make slight of such things as are of a very criminal Nature; for it is the Marvellous, rather than right Reason, that generally guides their Fancies. Thus, you see, it is no new thing for People to quit the Side of Truth for the sake of a bold, glowing Expression.

Chevalier. By your Leave, Sir, I cannot help thinking that Truth has here the Advantage of Fiction, even in this respect; for where is the Marvellous? Where is the fine Thought, or glowing Expression? Or, where, in short, is there any Reason or Sense in supposing that Gold or Marble should be created for no other End than to lie buried under Ground? Nay, there is Contradiction and Absurdity in the Supposition; whereas we become sensibly affected with Love and Gratitude towards Providence, while we look upon it as having an Eye to our Good in every Production of Nature, and as having assigned us our Lot where Plenty and Delight surround us on every Side, and provided for us such a vast Variety of Riches under our Feet, which are lodged in the most convenient manner, as on so many Shelves, one below another.

* — Itum est in Viscera Terræ:

Quasque recondiderat, Stygiisque admoverat Umbris,
Effodiuntur Opes, &c.

Metam. i.

Prior.

Prior. Let us now unlock these subterraneous Repositories, and see what they contain. But since we have free Access to the Count's Cabinet, we will, if you think proper, take a cursory View of some of those little Apartments, in which he has disposed, in Order, Samples of most of those Substances which we find under Ground: He has ranged the whole into five different Classes, *viz.* Oils, Salts, Earths, Stones, and Metals, each of which has its proper Apartment. The Door of the Cabinet opens like that of a Scrutore from the Top downwards, and being let down half way, is supported by a Rest, so as to form a kind of Table, whereon to lay any thing you take out of the Cabinet: In the Niches between the Partitions are written the Names of those Things they contain, and through a transparent Crystal you see distinctly every Particular, without taking it out of its Place. The three first Classes shall be the Subject of this Day's Entertainment; and we will reserve the Stones and Metals for another Time, when we make a Visit to the Quarries and Forges that are in the Neighbourhood.

The first Tire
of Drawers.

Unctuous Bodies.

The Oils and Juices, whether liquid or consistent, that are found under Ground, are Sulphur, Bitumen, Naphtha, and perhaps some others. These Substances are nearly allied to each other in their Nature, and seem to agree in their Principles by the Likeness of their Smell and other Qualities; but they vary in their Colour and Form, according to the different Sorts of Matter that are incorporated with them.

Sulphur.

The natural Sulphur is generally found in Places adjoining to Volcano's, though it is also to be met with in other Places. It will melt when put in a Pan, and set over the Fire; they then cast it in Molds, and send it to us in Cakes or Sticks. Notwithstanding the Fire with which this Body abounds, a Stick of it put into Water will cool it as effectually as so much Ice; for the Fire remains shut up within the finer Particles of it, while the Water only dissolves a small Salt which contracts it, and thereby hinders the external Heat from penetrating it as before.

One

One great Use made of Sulphur is to whiten Caps, and other woolen Manufactures. It is also a sovereign Remedy against any Infection from an unwholesome and pestilential Air; and different Preparations of it are used by Physicians in many Cases; and lastly, by mixing it with Salt-petre, Men have attained to the Art of making that murdering Powder with which they make such terrible Havock with one another, and which indeed would be of infinite Service in the Defence of Kingdoms, could Justice and Valour be proof against the mischievous Effects of it.

Nothing approaches nearer to the Nature of Sulphur than Bitumen, which is sometimes gathered under Ground in brittle Masses of a fat, inflammable Substance, sometimes like a glutinous Matter like the Pitch which distils from the Pine-Tree; though generally Bitumen boils up out of the Earth, and swims on the Surface of the Water, like a black Oil or Scum, which thickens to a Consistency after being exposed a little while to the Air; and in this Form it is found in certain Springs, and on the Waters of the Dead-Sea, or the Lake *Asphaltites*, which covers the ancient Valley of *Sodom*.

Petroly, or that Oil which runs from the Bottom of Rocks in several Countries, and Naphtha which has that peculiar Property of burning under Water, are only different Kinds of bituminous Bodies.

They are used in several medicinal Preparations, and in black Varnishes. In *Sicily* and other Places they burn them instead of Oil in their Lamps; it is also very common in most Countries to tar the Outside of Ships, the Cordage, and any thing which they would preserve from rotting in the Water, with a Composition made of these Ingredients.

Naphtha has a principal Part in those beautiful Fireworks which are played off on Occasions of publick Rejoicing, and probably made one Ingredient in the Composition of that sort of Wild-Fire invented by the *Grecians* about 717, so much taken notice of in the Histories of

Its Use.

Bitumen, or Asphaltus.

Petroly, or Rock Oil, and Naphtha.

those Times, and which stuck so fast to the Cloaths of those Soldiers on whom it was flung, that there was no Possibility of extinguishing it. The Art of making this Wild-Fire in Perfection was lost, it seems, by the Invention of Gun-Powder, which does but too well supply its Place.

Camphire which burns upon the Water like Bitumen, is perhaps nearly of the same Nature; but is not a Fossil, but a kind of Gum or Rosin which is voided by some certain Trees in *China* and the Island *Borneo*, at the Roots of which they find it caked together in Clusters of different Sizes.

Jet, which is so much esteemed for its beautiful Blackness, its Hardness, and for taking so fine a Polish, appears to be nothing but a sort of black Bitumen mixed with chalybeat Particles, and hardened by Petrifaction.

Yellow Amber is produced in the same manner, has the same Smell, and the same Elasticity or Power of attracting Straws and other light Bodies after being heated by Friction. We are informed by some learned *Prussians* *, that they not only seek for Amber at the Bottom of the Sea along their Coasts, whither it is driven by Storms and Tempests from where it is first formed, but that they find it also in the Earth in several Parts of *Prussia*, between Layers of vitriolous and bituminous Matter, which lie in Strata one above another like thin Planks of Wood. This Amber is one of the greatest Revenues the King of *Prussia* has, who is sole Proprietor of this Commodity.

Chevalier. I have often seen in the Cabinets of the Curious, Pieces of yellow Amber, in which one might discern Insects preserved in their perfect Shape. Now if yellow Amber were, as these Virtuoso's informed me, a Gum that hardened at the Roots of those Trees from which it distilled, one might easily account for these

* See the Dissertation of Mr. Hartman in the Philosophical Transactions abridg'd by J. Lowthorp, T. 4. P. 473.

little Insects being made Captives in it; but pray, Sir, by what Fetch of Philosophy will you account for Gnats and Beetles taking up their Lodgings under Ground, in the Heart of a Mass of this congealed oily Matter?

Prior. Nothing is more common among Insects than for them to shelter themselves under Ground against the Cold at the Approach of Winter, where they may very easily, in the Course of so long a Sleep, be surprized and surrounded by a Discharge of this Oil. Some are of Opinion, that there are *Germans* who have the Secret of softening Amber; but however this be, it is probable that those Animals which we sometimes see preserved in Amber, are rather the pretty Delusions of Art, than the Workmanship of Nature.

Chevalier. Do you derive the Formation of Ambergrease from the same Original, whose agreeable Smell is so very different from that of Bitumen?

Ambergrease
*Ambra, Amba-
rum.*

Prior. There is also a sort of Bitumen that has a very balsamick Smell *; such is the white Petroly or Rock-Oil of *Modena*; nor is it at all impossible, that the Water in its Course under the Rocks should carry with it certain odoriferous Oils, which afterwards swim on its Surface, and acquire a greater Degree of Frangency in the Air, by exhaling those Juices which might have too strong a Smell: And this is the Opinion of some Naturalists. Others take Ambergrease to be pretty much of the same Nature with Musk and Civet. The former is an Oil with which Nature has provided the Antelope, probably to give a shining Gloss to its Hair, and to preserve it from the Rain. This kind of Goat, so common in the Kingdoms of *Boutan* and *Tonquin*, carries this Provision in a Poke or Bag like the Castor, and pretty near in the same Part of his Body. Civet is taken in the like manner, from a sort of Cat or Fox, and which is called a Civet-Cat. Ambergrease, if we may credit some Authors, comes also from

Musk.

Civet.

* Sennertus de Bitumine,

a Sea-Animal of an amphibious Nature, which has an absolute Occasion for such a Provision wherewith to oil its Hair: But this is only mere Conjecture; besides, such great Quantities of Ambergrease have been found together, that it seems strained and unnatural to have recourse to such a Supposition: Others will have it to come of a still meaner * Extraction: In short, there are various Opinions, but nothing certain yet discovered, touching the Origin of Ambergrease.

Chevalier. Pray for what Use were all these Oils that you have been enlarging upon designed? I do not see how they can be serviceable in any respect under Ground.

Prior. Those different Oils being variously distributed under Ground, mix with the subterraneous Waters, and run into the Sea, from whence they are exhaled together with the Vapours, but dispersed in such small Quantities as not to affect the Senses, when they first descend with the Rains upon the Earth; but afterwards collecting their scattered Forces, and uniting with the Salts which they meet with on the Earth, enter into the Substance of Vegetables, and become the Principle of those sweet Savours and Smells which regale our Senses in Plants, Flowers, and the Flesh of Animals.

Chevalier. Here is a Catalogue of strange Names with a Witness on the Phials of this second Repository. *Sal Gemmae*, Nitre, Salt-petre, Vitriol, Borax, Colcothar, Arsenic: Their very Sounds are enough to frighten one.

Prior. They are Names of Things, it is true, which may do a great deal of Mischief; but you will presently see how happy we are in being possessed of them.

Salt, which makes one Ingredient in the Composition of all Bodies, and seems appointed to be the Cement of the whole System, is, generally speaking, an Element of a hard, inflexible Nature, whose smallest Parts have several Sides or flat Surfaces, their Extremities end-

II. Tire of
Drawers.
Salts.

The Use of
Salts.

* *Quibusdam videtur esse Stercus Balanarum.*

ing in Points: It varies both in its Sorts and in its Effects, whether by reason of its incorporating with other heterogeneous Matter, or because the Particles of which it is composed are of different Configurations: Though, perhaps, both of these Causes may concur in producing different kinds of Salt.

The little *Lamine* of Salt that are found in all Bodies, upon their undergoing a Separation by Fire, are probably appointed to fix and hold together, by their Points and Angles, the Parts of other Elements; being, as it were, so many little Pegs which penetrate the Pores of other Bodies on every Side, and fasten them close together: But as the Pegs and Nails which serve to join one Body to another, may, when they are too large or too numerous, become like so many Levers, and serve only to displace them, or as so many Wedges to cleave and rend them asunder; so in like manner, the Salt may oftentimes break and dissolve them instead of pinning them together. But it does not produce these Effects immediately of itself, any more than the Nail can act upon Bodies, and force its way into them, without being driven by the Stroke of the Hammer; but it is driven by the Percussion of the Spring of the Air between the Interstices of the other Elements, according to the greater or lesser Degree of Force with which it acts on those Bodies that are near it: It may also be impelled by the Action of other Bodies pressing upon it: And as Salts do enter into the Pores of all Bodies, so likewise the Water, which is still of a more subtle Nature, does insinuate itself between the Particles of Salt as well as those of other Bodies, which being dissolved and put in Motion by the Action of the Fluid, do constitute a Menstruum of floating Corpuscles, which naturally precipitate when the Fluid is in a State of Rest. By this dissolving Power of the Water, it becomes the principal Vehicle of the Salts which it conveys into the Pores of all Bodies, where it leaves them to execute their proper Office.

Nor is it only the Action of Fluids on the Surfaces of the saline Particles, that keeps them fluctuating in those Fluids, seeing it is not to be doubted but that there are Bubbles of Air contained in those very minute Corpuscles, which

which render them as light as an equal Bulk of the Fluid in which they swim.

Those Salts which are conveyed in a Vehicle of Water, or impelled by the Spring of the Air into the small Cavities of Bodies, or into other Pyramids of Salt, do make their Entrance by one of their Angles or Points, the better to facilitate their Passage. All the Particles of Salt apply their flat Surfaces together, and preserve the same determinate Figure: The finest Grains of our common Salt seem all cut into eight Angles and six Sides, like a Die, and consequently this sort of Salt chiefly consists of Masses which are of a square or cubical Figure. The Particles of Alum exactly resemble Pyramids. Nitre, as well as Crystal, consists of Parts that appear to have six Sides, and which, by lying one upon another, form a sort of hexagonal Columns. Vitriol is composed of Lozenges. The Parts of Arsenick are more flat, but extremely sharp and pungent. All these Salts, whatever be the manner of their Association, do always form themselves into Masses of one regular Figure, which never varies. Our Adepts * in Natural Philosophy have taken great Pains to account for the Regularity of all these crystalline Bodies; they have called Geometry in to their Assistance, and attempted to establish their System on nothing less than Demonstration; nay, some of them have gone so far, as to take the Liberty to abuse others for having mistaken triangular for hexagonal Figures. I am too sensible of my own Insufficiency to bear any part in these learned Disputes; and therefore will content myself, my dear *Chevalier*, with making one Remark very obvious and reasonable, and which is of more necessary Use to you than an exact Knowledge of all these Figures; *viz.* If all the Particles of which every particular sort of Salt is composed, do, either in falling one upon another, or uniting on one common Base, form themselves into Masses which are always of the same regular Figure, we must hence conclude, that all these Salts were from the Beginning cut and fashioned by the same Hand, and formed by one

* You may see on this Subject, *The Dissertations of Guillelmini, Hartsoeker, Lewenhoeck, Robert Boyle, the Letters of Mr. Bourgeut on the Formation of Salts, Mr. Lemeii's Course of Chymistry, and the Memoires de l'Academie des Sciences.*

uniform, invariable Model. Motion impressed on Matter could not possibly act with so much Order and Regularity ; and therefore every Grain of Salt must have been created of this or that particular Figure rather than of any other, on purpose to produce this or that particular Effect. We may therefore observe of the least Pyramid or Grain of Salt, as we before did of the smallest Bubble of Air, that both the one and the other do as fully demonstrate the profound Wisdom, Counsel, and free Agency of their Creator, as the Sun and the Earth. We may now proceed to take a cursory View of the different sorts of Salts which he has shaped for our Use, and which are so many Gifts bestowed upon us by our kind Benefactor.

Chevalier. I was little sensible of the Obligations we lie under to him for these Benefits, nor indeed was it possible for me, seeing I am not only unacquainted with their Virtues, but even with their very Names.

Prior. The three first sorts of Salt that you see here placed together in these three Glasses, are *Sal Gemmae*, or Mineral Salt, Sea Salt, and Well Salt ; though these three are originally the same. The Water of the Deluge did probably leave under Ground great

Sal Gemmae, or
Mineral Salt,
Sea Salt, &c.

Quantities of that Mineral Salt which is found there, and which is as hard and bright as Crystal. The Rain which soaks into the Earth, and forms subterraneous Currents, passing through these Beds of Salt, dissolves greater or lesser Quantities of it, and conveys it to the Salt Wells. You know how this Salt is separated from the Water by Ebullition *, as the Sea-Salt is by Evaporation †. All these Salts, though of the same Nature, vary their Colour and Quality by being mixed with heterogeneous Matter ; which is the Reason why the Salt of some Coasts, as for Example, that of the Coasts of *France*, is more esteemed than any other.

Chevalier. Our common Salt is naturally of a fallow Complexion inclining to black ; by what Art then do they bring it to a Degree of Whiteness equal to that of Snow ?

* See Page 82.

† See Page 73.

Prior. The most plain and simple Way of doing this is to put a certain Quantity of grey Salt in-
 to an earthen Vessel, allowing a Pint of
 Water to every Pound of Salt: They then
 let it stand some Days till the Salt is all
 dissolved, in which time the Dirt and
 other terrestrial Particles subside to the Bottom. They
 then gently pour off the Water from the Sediment into
 another Vessel, and boil it till it evaporates, leaving the
 saline Particles behind, which, as the Water goes off in
 Steam, coalesce in little Masses, and precipitate to the Bot-
 tom of the Vessel: The whiter the Salt, the cleaner and
 purer it denotes itself to be: It becomes still whiter when
 filtrated through a Bag of Cloth-Lift: But these Ways of
 preparing Salt are so far from perfecting or improving it,
 that they take away part of its Strength, and make it insipid.
 We may also infer from its not crackling when cast into
 the Fire, as the grey Salt does, that the latter contains
 Bubbles of Air, which, being rarefied by the Heat, burst
 their Cells, and give a Crack. Now as this Air is in our
 Bodies a Principle of Motion, it does consequently help
 Digestion better. But after all, it is neither the Eye, nor
 the Reason, nor yet any uncertain Collections drawn from
 the Analysis of Bodies, that must judge of Tastes and Sa-
 vours, we must leave that to the Decision of the Palate, as
 its proper Office and Province.

Next to our common Salt, Nitre, or
 Nitre. Salt-petre. Salt-petre, is of most general Use; and
 this is found sticking on the vaulted
 Roofs of Caves and Cellars in old ruinous Buildings,
 especially where Animals have urined for any Continuance
 of time: Nitre seemes to be a volatile Salt, exhaled from
 Caverns and hollow Places under Ground, through the
 Pores of the Earth into the Atmosphere, where it is dis-
 persed like the Sea volatile Salt, both the one and the
 other, together with the Fire and Water, constituting the
 Principles of Vegetation and Fecundity. But whence-
 soever Nitre first proceeds, it is past all Doubt that it is
 carried about in the Air, which is continually fed with
 fresh Supplies of it, though this Salt does gather in greater
 Quantities in those Places where it is at Rest, and has
 Leisure to accumulate in larger Masses. Perhaps it may
 be

be proper to distinguish betwixt Nitre and Salt-petre, and to define the former to be a volatile Salt, floating in the Atmosphere, this or that way, as the Wind directs; whereas the latter is the same Nitre, but fixed and incorporated with other Bodies, and in particular having much compressed Air contained within those *Laminae*, or thin Layers, of which it is composed. You will immediately see the Use I design to make of this Remark.

The Method they take to collect Salt-petre, is either by sweeping it together from off the Stones and Walls of old decayed Buildings, or by putting the Sweepings and Rubbish in hot Water, in order to dissolve the Salt; the Water in which the Dissolution is made, is afterwards poured off; the Water evaporates, the Salt crystallizes, and settles to the Bottom, and is afterwards refined by different Lotions. Of this Salt are made many sovereign Medicines, as are also distilled from it some Waters of so strong and penetrating a Nature, as to dissolve Metals, and reduce them into Liquids: But the Power of this Salt is in nothing more conspicuous than in Gunpowder, of which it is the principal Ingredient; in this Capacity, it decides the Quarrels of Kingdoms and Nations, and Salt-petre oftentimes proves irresistible, where the most powerful Arguments of Reason could not prevail.

Chevalier. Methinks, Sir, the Remark which you just now made of the Air's being shut up within the Particles of the Salt-petre, explains the Reason of that surprizing Force, with which a little Gun-powder impels such a heavy Mass of Iron: For this imprisoned Air is no sooner acted upon by the Fire, than it endeavours to expand itself, and being resisted on every other Side, forces its way with great Violence through the Mouth of the Cannon, driving the Ball before it with such amazing Velocity.

Prior. This is the chief Cause of the Force of this Powder, and we have a Proof of this, in that Explosion with which the Air breaks loose from its Confinement within the

The Effects of
Gun-powder.

Salt-petre, upon its being cast into the Fire. Common Salt, which can inclose but a very few Particles of Air in the time of its Crystallization in the Water, does also give a Crack when flung into the Fire; but

but not so loud as the former. To the Air which is essentially contained within the Salt-petre, let us add that which is necessarily mixed in with it, as also with the Charcoal, and the Sulphur, at the time of reducing them into Powder ; as also that Air which occupies the intermediate Spaces between the Grains. All these Sums of Air do together constitute a Quantity, whose expansive Force is in Proportion to the Degree of Heat that rarefies it. Now it is easy to conceive the Force of the Fire, when a single Spark proves sufficient to set at Liberty those first Particles of Fire, which it is sure to find imprisoned in the Charcoal and Sulphur. As the fiery Corpuscles break loose from their Confinement, their united Strength proportionably increases, the first Prisoners that are released, breaking open those Cells that hold their Companions in Durance, and giving them their Freedom. Thus do these collected Forces act with united Strength on the imprisoned Air, which being put in Motion by so intense an Heat, exerts its utmost Elasticity, and violently strikes on those inflexible sharp-pointed Salts that surround it ; upon which they immediately dart forth like Millions of Arrows, shot from as many Bows of Steel. The Resistance from the Sides of the Cannon being equal, no lateral Motion of the Cannon can ensue ; but as the Powder acts nearly with the same Force on the Breech of the Cannon, and on the Ball, which it forces through the Aperture of it, the *Momentum* *, or Quantity of Motion, must be nearly the same in both ; now as the Cannon is two or three hundred times heavier than the Ball, if the Cannon recoils one Pace, the Ball must fly two or three hundred Paces in the same time, in a contrary Direction.

Chevalier. The same Argument, I fancy, would account for the Ascent of Rockets, or Fire-works, in the Air ; for the Powder in them being equally resisted by the Sides, does not act in a lateral Direction, but spends its Force on the two Extremities of the Rocket, emptying it-

* The *Momentum* or Quantity of Motion in any Body is compounded of its Velocity and Weight ; if therefore, in the present Instance, the Quantity of Matter or Weight of the Cannon be three hundred times greater than that of the Ball, if we suppose the Cannon to move one Pace in any given Time, its *Momentum* or Quantity of Motion will be equal to that of the Ball, moving three hundred Paces in the same time.

self through the Orifice or open End, and causing it to ascend by its Impulse on the other End.

Prior. The Rod or Stick that is fastened to the Rocket, being made so long as to be equal in Weight to it, keeps these two Forces acting in one perpendicular Line of Motion ; so that the Rocket may discharge the Fire in a strait Line downwards, whilst it is made to ascend in a strait Line upwards. The Ascent of the Rocket, and the Recoiling of the Cannon, both proceed from the same Cause ; the Difference betwixt the Weight of the one and the other, being the only Reason why the former mounts up to a great Height in the Air, and the latter recoils but a little way back. Let us now pass on to the next Salts.

Alum, which you see here of two or three Sorts, is a Salt which is found in large Masses, naturally crystallized, and mixed with a little Earth, or some other Bodies. Feathered Alum is found in small Pieces, two or three Inches thick, and is composed of a great Number of fine strait Filaments or Fibres, white and brilliant like Crystal, and which form a kind of Tuft much resembling the Fringe of a Feather. This kind of Alum is brought from *Egypt*, *Sardinia*, and *Milo*, an Island of the *Archipelago* : It is very scarce.

The *Roman* Alum is a Salt, that is found in red, transparent Stones, as the Roche or Rock-Alum is in a sort of white Stones, that are bright, and sometimes very large ; and from these they gather this Salt, as they do Salt-petre from Stones and Rubbish. The Principles of which Alum is composed, are of a very restraining Nature, which is the Cause of its contracting and binding whatever it is dissolved in ; upon this Account it is much used by the Dyers and Stainers, it being as it were the Cement which unites and incorporates the Colours with the Stuffs, and agglutinates the different sorts of Ink to the Paper : Were it not for the Alum, the Ink would sink into the Paper, and the Air would wear off the Colours from the Stuffs, or at least take off their Gloss, and make them fade immediately.

Alum.

Feathered Alum.

Roman Alum.

Vitriol

Vitriol.

Marcaffites.

Sulphur, Salts, and metalline Particles. Vitriol varies in Properties and Effects, according as it partakes more or less of the Nature of Copper or Iron. That which has the fewest Particles of Metal mixed with it is white; the other sort are blue and green; the former comes from *England* or *Italy*, and partakes of the Nature of Iron; the blueish Green is brought from *Germany*, and is of the

Chalcitis.

Nature of Copper; the Sky-blue, which also contains much Copper, is brought from *Cyprus* and *Hungary*. These crystallized Salts when calcined, whether naturally in the Mines by subterraneous Fires, or artificially by our common Fire, yield a red Vitriol, which has the Property of stopping Blood.

Chevalier. Is it not of this Salt they make your Sympathetick Powder, which they relate so many marvellous things of?

Prior. It is nothing else but *Roman* Vitriol dissolved in Water, and calcined several Times in a hot Sun. But this Power has pretty well lost its Credit, and the wonderful Effects which are ascribed to it, pass with many sensible People for nothing but mere Hear-says, without any Proofs to support them. The chief Virtue of Vitriol is to facilitate the Composition of Dyes and Colours, particularly that of Ink: A happy Invention this, which enriches us with every thing that has been either said or thought in former Ages; which procures us the Pleasure of conversing with our absent Friends, and the Advantage of holding a Correspondence with the Inhabitants of the whole Earth. The Composition of Ink is of all others the most plain and simple: The Gall-Nut and the Vitriol are the fundamental Ingredients, the Gum and the others, which are not so essentially necessary, serving only to thicken, and give a greater Body to the Whole: The saline Particles, or the Points of the Vitriol, insinuate themselves into that spongy Matter, of which the Gall-

Nut

Nut is composed. The metallick Particles therefore, especially those of the Iron, being no longer fastened and held together by these Salts, disperse themselves into all Parts of the Liquor, and make it more or less black in Proportion to the Quantity there is of them. For this Reason, the Vitriol which is gathered in the Copper-Mines, being of a lighter Cast, is not so proper for this Use, as that which is taken out of the Iron-Mines.

The Borax is another Salt which is found in the Mines, especially those of *Borax. Chryso-*
Persia, from whence it is brought to the *colla.*
Mogul at *Amadabat*; and hence it is that the *Europeans* fetch it. They dissolve it in Water, and filtrate it through Paper, and crystallize it: Before it is refined by these Operations, it is rough, greasy, and unfit for Use. It is much used by the Goldsmith in soldering Metals, and to collect the little scattered Particles of Gold.

Arsenick, which is taken from a mineral Stone called *Cobalt*; Orpiment, which is another kind of Arsenick; and Realgar, which is a calcined Orpiment, are all deadly Poisons, against the fatal Effects of which, there is no other Remedy, but immediately drinking Oil, to sheath the Points of these pungent and caustick Salts: However, great Use is made of these stimulating Drugs by Physicians in outward Applications; they do also enter into the Composition of several Colours used by Dyers and Painters.

Besides the Salts already mentioned, there are others had in great Use, as the Sal-Armoniac, which is chiefly made of Soot, and the Urine of Animals, burnt in a very hot Sun: Tartar, which is nothing else but the most saline Particles of Wine, fixed and crystallized into a Crust, round the Insides of Casks; and Verdi-grease, or Vert-grease, which is the Rust of Copper corroded by Salt-petre, or incorporated with the Tartar of the Husks of Grapes, after they are pressed, and laid on thin Plates of this Metal.

Arsenick.

Orpiment.

Realgar.

Sal-Ammoniac.

Tartar.

Verdigrease.

All

Acid.

All these Salts, as well as others, consist of two Parts, the one called Acid, the other Alkaline. The acid Part is a Collection of angular *Laminae*, cut Faucet-wise, always very acute, and oftentimes having a sharp Edge, but withal so fine and light, as to swim in the Air, and in Liquors. Acids may be said to form a Fluid of themselves, and never to consolidate into a Body, but when they meet with a Basis suitable to them, that is to say, some porous Matter, proper to sheath and fix them.

Alkali.

The alkaline Part is nothing else but that Basis or porous Matter, which serves to unite and fix the Acids. The Acid is sharp on the Tongue, and seems to pierce it; the Alkali has a tart burning Taste. From the two Principles, so different from each other, is formed the neuter or compusite Salt, such as the Sea-Salt, Salt-petre, Vitriol, and other common Salts. Whether the divine Wisdom has constituted but one Acid in Nature, which varies its Effects according to the different Basis prepared for it; or whether the Hand of God did from the Beginning cut and fashion Acids with different Points, and adapt different Sheaths or Cases to them; however this be, it is certain that these Principles do always continue to unite or separate in the same constant regular manner, and to be serviceable to us, whether in a State of Union or Separation.

After having separated these two constituted Parts of the Salt by Fire, they convert the Acid and Alkali to their respective Uses. From the former they extract strong corroding Waters, which will dissolve the hardest Metals: A noble Invention this! but I shall make this the Subject of our Entertainment in a more proper Place.

Nor are Alkalies of less Use. The way to know Alkaline Masses is this: As the Fire, which forces the Acids out of these Bodies, does insinuate itself into their Places, and, together with the Air, take Possession of all the vacant Apartments; if you pour upon these porous Masses any Liquors that are replete with acid Salts, the sharp Points of the latter dart into the Pores of the calcined Salts, and drive out the Fire and Air lodged therein; upon which immediately ensues an Emotion and Ebullition

tion in the Menstruum. This Ebullition is what we call Fermentation, and is the Characteristick, or distinguishing Property, of an alkaline Salt.

As the Salts which are extracted in great Quantities from a Plant called *Kali*, by reducing it to Ashes, were those in which they first discovered the Aptitude or Fitness of these Pores to sheath the Points of the Acids; they therefore gave the Name of Alkali or Alkaly to all Salts thus penetrated, whether calcined by the Sun, or common Fire. Let us see the Use they make of them.

These sorts of Salts, which are chiefly found in Ashes well boiled, are the best whereof to make Lye for the washing of Linen, or to scower Cloaths, they being subtle enough to insinuate themselves with the Fluid they are mixed with betwixt the finest Threads of Stuffs or Linen, and withal sufficiently spongy and porous to imbibe all the little Particles of Oil and other Matter which transpire from the Body into them. You see, Sir, how so contemptible a Matter as a Heap of Ashes, which one would think fit for nothing but to be cast on the Dunghil, supplies us with an Ingredient which of all others contributes most towards keeping us clean and wholesome.

Here also take Notice of a Composition which is still more serviceable to us. These same alkaline Salts which are extracted from Wood, Sea-weed, Salt-wort, and all sorts of Plants when burnt to Ashes, being mixed with Sand, and melted over a hot Fire, constitute the Substance of Glass, which is serviceable to us in so many respects. The Fire, by putting in Motion those Parts which are hard and inflexible, purifies and cleanses them from the Dross, and other extraneous Matter; as the Heat abates, the purer Particles fix and incorporate by subsiding one upon another, forming so compact a Body as not to be penetrated by Liquors, or the grosser Parts of the Air; but the Light being infinitely more fine and subtle than the Air, gains free Passage through those innumerable rectilineal Pores occasioned by the Transition of the Fire through the Matter of which the Glass is composed in strait Lines.

Chevalier. The Alteration caused in the Salt by the Fire is very unaccountable; it leaves the constituent Parts

of it entire, and yet gives them a quite different Form; and the Salts which were before in a Disposition to enter into the Composition of all Bodies, when vitrified by the Fire, convert into hard inactive Masses, which neither the Air nor the Water can penetrate, nor are any longer capable of mixing with any other Bodies.

Prior. And yet in these shapeless and seemingly useless Masses of Glafs, we are able to trace the Footsteps of that same infinite Wisdom and Design which is displayed in every other Part of the Creation. When this vitreous Substance is melted by a hot Fire, they dip the End of an iron Tube into it, and therewith take up a little Quantity of this burning Liquid; the Artist blows through the Bore of the Tube, and the Glafs, which is made ductile by the Fire, immediately obeys his Blast; it swells, it spreads, it forms itself into a Bottle, a Bowl, a Cup, or a Tube several Feet long; he turns it and twists it, he makes it round as a Ball, or flat as a Washer; he cuts it with Scissars like a Piece of Cloth, and, in short, fashions it into ten thousand pretty Fancies, or convenient neat Vases for keeping and preserving Liquors, in which Capacity it serves better than the most precious Metals.

Instead of being at the great Expence of building Windows to our Houses of white Stone cut into thin *Lamina* or Plates, in order to make it transparent, as it seems was the Practice of the Ancients; instead of using Canvas or Linen Cloth for this Purpose, which intercepts our View, and obstructs the free Transmission of the Light; or instead of making Lattices, which would expose us to all the various Impressions of Cold, Wind, and Rain; how much more convenient for us is it to have our Houses adorned with such thin transparent Walls of Glafs, which though sufficiently dense and compacted to secure us against the Inclemency of the Weather, yet are so pellucid as to transmit to us in the middle of our Houses, the cheerful Blaze of Day without any Diminution of its Lustre, and lay open to our View the whole Prospect of Nature!

Glass may be either painted externally or stained internally in the Composition. When they only paint the Surface of it, they seal it to prevent the Incrustation of the Colours from sinking to any Depth in the Glass. By this means you have transparent Pictures as perfect as any drawn by the most masterly Hands on any other Materials. When the whole Substance of the Glass is stained quite through, they do not draw upon it human Figures (for these would seem awkward and confused); but by means of those Ramifications of Lead which keep the Panes together in the Frame, they run it into several Divisions and Compartments, which delight the Eye with a Variety of regular geometrical Figures of the most beautiful and lively Colours. But as the Beauty of an Edifice within does chiefly consist in the Lightfomeness of it, the Fashion of painting or staining Glass is very much laid aside, except in the Borders of large Windows, which they now and then embellish in this way; though since the Use of clear pellucid Glass has so universally prevailed, this Art of painting on Glass (which produced so many Master-pieces of this Kind in the sixteenth Century) is almost entirely neglected. As to what is generally affirmed, that the Art of painting upon Glass is lost, it is without Foundation, seeing that of Enamelling is still in Use, which is the same Art with the other, but only in Miniature: Glass, Pewter, and Lead, with certain coloured Earths, are the Matter of the Enamel, and which will stick to Metals for a long Continuance of Time. The Colours are mixed over the Fire of a Lamp, which is made hot enough to melt them; the Artist first draws out his Colours into fine Threads or Strings like those which proceed from a Stick of melted Sealing-wax, and these he draws to what Length he pleases; having made this Provision, if he has any Device to enamel, he melts at his Lamp the Extremity of such of these Threads as he has Occasion to use, and immediately applies it to that Part of the Figure he is upon; and thus with much Patience, as well as Dexterity, he pursues his Work.

Painting on
Glass.

Enamel.

The Ductility of
Glass.

The Degree of Fineness to which they have the Art of drawing Glass is almost incredible; under this Operation it loses its friable brittle Quality, and becomes ductile and pliant. The Artist with a Hook draws a Thread out of the melted Matter, and fastens it on a Reel; he then turns the Reel, and winds the Thread round it, which continues to spin from the molten Mass till the whole is spent; this done, he cuts the Threads that are wound round his Spinning-wheel, and there remains in his Hand a Sheaf of long white Fibres of Glass, of which they make those counterfeit Egrets or Bugles which adorn the feathered Caps of little Children, and spangle the Diadems of theatrical Kings. But to pass over the different Ornaments they make of Glass, and the Secret which the Proficients in this Art have found out to imitate, at little or no Expence, the Lustre and Diversity of precious Stones, let us speak of that more useful Invention in working Glass, and which is a more deserving Object of our Curiosity, I mean those Glasses of several Sorts which are now so universally in Use. The *Venetians* were the first that found out the Art of giving a perfect Polish and Transparency to Glasses, and of bringing them to the Height of fifty Inches; but we have so well copied from them at *Tourlaville* near *Cherbourg*, in Low *Normandy*, that we have no Occasion to be obliged to the *Venetians* for this Commodity: But they have now got the Art of making them in still greater Perfection at the Castle of *St. Gobin*, three Leagues from *Laon*, where they have brought them to the Height of a hundred, and even a hundred and twenty Inches, which is the highest Degree of Magnificence. Nor do they blow them here as they do at *Venice* and *Cherbourg*, but run them on a Table of Brass or other cast Metal.

Chevalier. If you have seen them run these Glasses, be so kind, Sir, as to inform me how they do it.

Prior. I will just give you the chief Particulars. The Matter of which it is composed is nothing else but the Salt-wort* of *Alicant*, and the finest Sand of *Creil*.

The Matter of
Glass.

* This Plant is called indifferently by the following Names, *Kali*, *Kalt*, *Salt wort*, or *Glass wort*.

The Salt which is extracted from the common Salt-wort and common Ashes, when mixed with Sand, makes the common sort of Glafs. The best sort of Salt-wort and finest Sand make Looking-Glasses and Crystal, as the Glafs-workers term it, though indeed it is nothing but Glafs; for the true Crystal is a natural Stone.

The Matter most proper whereof to build their Furnaces, and Vessels in which they melt their Glafs, is a kind of Earth not very common; that of *Belriere*, a Place near *Forge* in *Normandy*, is esteemed by the Glafs-makers the best for this Use, seeing of all the Earths they have made Trial of hitherto, this stands Proof the best against the Power of the Fire, which calcines, cracks, or by Degrees vitrifies all others. The Furnace.

The Furnace must be repaired every six Months, and entirely rebuilt every three Years. It is surprizing to behold with what Dexterity the Workmen go through this dangerous Business, and how artfully they manage the Tools with which they take hold of the Pot that contains the burning Liquid, how they stoop it, and pour the fiery Torrent upon the Table which runs into the Mould. Upon this Table are placed little iron Rods or Rulers, which, according as they are placed, determine the particular Breadth and Size of the Glafs: But nothing can come up to that Degree of Nicety and Cleanliness with which they take care to conduct the whole Work; for any the most imperceptible Grain of Dust (as Experience often shews) is sufficient to make a Glafs of a thousand Crowns Value miscarry in the making; for the least Particle of Air lodged within that Grain of Dust, is no sooner acted upon by the Fire, than it dilates, and forms in the Body of the Glafs a Bubble, oftentimes of a very large Size, which either cracks, or at least disfigures it. When the melted Matter is poured upon the Table, they spread it equally betwixt the Rulers, and make it from one End to the other of an uniform Thickness, by pressing it with a large brass Roller, the Extremities of which run upon the iron Rulers. The chief Thing to be taken care of in making the Glafs is, that the external Surface does not cool whilst the Inside remains still liquid, or at least very hot. When the Glafs is placed near a Fire which abates by Degrees, the

gradual Decrease of the Heat causes the Glass to fix and consolidate equally in every Part ; whereas, if the external Superficies hardens immediately, while the Fire acts powerfully in the Heart of the Glass, when the Fire comes to force its way through the Pores of the Glass, or happens to be condensed within it for want of free Liberty to act, it will leave a Vacuum, which not being able to make any Resistance to the Pressure of the external Air, it does immediately break it in Pieces.

The Glass-Drop.

Chevalier. I have a Notion that one might account this way for the breaking of the Glass-Drop, which you some time ago shewed me how to reduce to Dust by only breaking off the Neck. The Drop being let fall red hot into cold Water, the external Superficies hardens into a Crust, whilst the Fire still possesses the Inside of the Drop, which, getting loose, leaves a hollow or void Place within the Crust. Now the Reason of the Drop's not being broke by the Pressure of the external Air, is because of the Rotundity of its Figure, which forming a convex or arched Vault round the vacant Space, supports itself under the Weight of the incumbent Air, by resisting it equally on every Part : Whereas by breaking off the Neck of the Drop, you make a flat Surface of the Air to act upon, which meeting with no Resistance from within to counterbalance its Pressure, it crushes it to Pieces.

Prior. If this Solution of the Matter is not more philosophical than many others, it is at least more short and simple. But to whatever Cause we are to assign the Breaking of Glass, which cools too fast, they take care, by way of Precaution, to neal all their Glasses, that is to say, to keep them a long time in a Furnace, the Heat of which they assuage gradually. When they have cast the Glass in the Mould, they move the Brass Table (which weighing twelve or fifteen thousand Pounds, is made to run upon Wheels fastened to the Feet of the great Frame that supports it) near to the Mouth of the nealing Furnace ; and gently slide the Mould with the Glass, yet undulating and liquid, on the Sand with which the Bottom of the Furnace is covered. After ten Days, when it is sufficiently nealed and consolidated, they

they take it out, and imbarck it on the *Oise* for *Paris*; where after it has passed through the Hands of proper Artizans, from a rough opake Mass it becomes as transparent as Crystal, and smother than Ice itself.

Chevalier. Pray let us follow it through all its Metamorphoses. And here, Sir, be pleased to inform me how they make of it a Mirror or Looking-Glass.

Prior. A Layer of Quick-silver and a Leaf of Pewter applied to one of the Surfaces of this Glass, do so exactly reflect all the Rays that fall upon it, that the white Leaf which reflects them is invisible at the same time that all the Objects from which those Rays are emitted, are clearly discerned. Thus does this smooth Plain become a Picture far superior to the most finished Pieces of *Raphael* and *Rubens*. Nor does it, like them, exhibit only one and the same Representation, but several successively: When a grand Company is in the Room, it presents you with a magnificent Show of different Groupes of Figures: If you open a Window to the Fields, it strait displays a beautiful Landskip; or if it reflects but a single Picture, it is drawn to the Life without Flattery or Disguise.

Chevalier. Here is indeed a very fine Metamorphosis caused by the Fire in a Heap of Salts and Sand.

Prior. There are still more surprizing Compositions made of these Materials, as your concave or convex Glasses, which, according as Concave and convex Glasses. they are placed one before another, disperse or collect the Rays of Light, so as to produce several advantageous, at least entertaining, Effects. Of these Glasses there are some which help weak Eyes, or short-sighted People; others that will burn any Object held at a certain Distance from them: There are some of them that discover to us the Motions of the least Animalcule, The Microscope. and the Organization of Bodies so minute as to be imperceptible by the naked Eye; and lastly, There are Glasses that bring very remote Objects near us, and help us to discover in the heavenly Bodies certain Motions, and other Particulars, which before this Invention we had not the least Notion of.

How a few Bits of Glass and Metal can be so put together, as to be able thus to discover to us the Mysteries of Nature, is a Subject, my dear Chevalier, worthy your Curiosity. We might entertain ourselves very agreeably in discoursing on the Structure and Effects, both of the Microscope and the Telescope; but especially those of the reflecting Telescope, which the ingenious Mr. *Scarlatt* has brought to so great a Degree of Perfection *. We might, with new Wonder and Delight, follow the Rays of Light through all their various Reflections and Refractions, their Convergings and Divergings, and all their different Inclinations in the different Mediums they pass through. This may be the agreeable Subject of Conversation some other Opportunity. But let us at present go on with our Catalogue of subterraneous Bodies: Besides Oils and Salts, we have under Ground Earths of numberless Sorts and Uses.

In discoursing upon Gardening we before remarked, that there are three sorts of Earth specifically different from one another, *viz.* Sand, Clay, and Loam †. The Sand is composed of Particles, hard, inflexible, impenetrable by Water, and transparent like Crystal.

The Clay probably is composed of Particles that have a cubick Form, and cohere together in close Contact; or perhaps they may be made to branch out in several Ramifications, with which they cling to and twine round each other; but however this be, it is certain that they are smooth, fat, slippery, ductile every way, tenacious, and admit no Water into their Pores.

* Mess *Godichon* and *Paris*, who live with Mr. *William Desprez*, in the Parish of *St. Hilary*, make the reflecting Telescope in as great Perfection as the *English* Artist here mentioned. I have compared theirs with mine, which is of Mr. *Scarlatt's* making, and find that mine takes in a greater Compass to the View, but that of theirs is more clear and distinct, which is a greater Perfection in Glasses.

† By the original Word *Limon*, here translated *Loam*, must throughout this Chapter, be understood the common black Earth or Mold, which is the true vegetable Earth; and this Sense of the Word is warranted by that short Character given of it in p. 232. Our Author in his Second Volume of this Work, discoursing on Gardening, describes it to be a Medium between Sand and Clay, &c. The Word *Loam* has also a more restrained Sense, and signifies Marl, or common Clay, with a small Admixture of Sand in it. See *Woodward* on Fossils, p. 4.

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The Loam or oozy Earth is composed of Leaves that fold themselves into hollow Pipes or Tubes, which render it spongy and easy to be penetrated by the Air and the Water. The different Effects of Water on these three Sorts of Soil, do evidently demonstrate the essential Difference between them. If the Water be poured on a Heap of Sand, it will fill the Interstices betwixt the Grains of it, without penetrating into the Grains themselves; and whether the Water enters into it, or drains from it, the Mass of Sand remains the same without increasing or diminishing its Bulk. If Water be poured on a Bed of Clay, it may perhaps just enter the Surface through those little Avenues which some Particles of extraneous Matter intermixed with the Clay may open to it; but it will not be able to penetrate deep into the Body of the Clay. Lastly, Water poured on a muddy oozy Earth will penetrate into it, and make it swell, and find free Liberty of Ingress and Egress.

This Distinction of three primordial Earths does also very sensibly demonstrate itself in Gardening and Masonry. If the Inside of a Terras be composed of Sand, Gravel, or Flints, the Water that falls upon it, whether it lodges any time in it, passes through it, or evaporates from it, will not produce any Alteration either in the Terras or the Wall that lines it. In like manner, if the Terras be built of good unmixed Clay, (if a sufficient Quantity of it may be got for that Purpose) the Water will not be able to penetrate it, nor consequently to make any Impression or Change in it; but will run from off it, and the Lining or Wall will keep its Perpendicular without bulging out. Whereas, if it be made of any Earth that first comes to hand, the least Quantity of Loam mixed with the other Earth, will inevitably cause the Parapet-Wall to give way and recede from its Perpendicular; for as the Rain-Water not only fills the Interstices of the Gravel and Sand, but also insinuates itself into the Coats and Pores of the Loam, all the Particles of the latter become like so many little Sponges, which swell and occupy more Space after the Intromission of the Water into their Pores. By thus dilating themselves they repel the contiguous Matter, and from the united Force of all their particular Impulses, arises a general Tumefaction or Swelling in the whole

Body of the Terras, which pressing with great Power against the lining Wall, causes it by Degrees to bulge outwardly : And though all possible Precaution has been used by making Drains at proper Distances for the Water to run off, yet the perpetual Action of the Earth upon the Wall, which swells and contracts by turns as the Water penetrates into it, or is evacuated from it, will in time destroy a Work which seemed sufficiently fortified by its Strength and Solidity against all Accidents whatever.

After having pointed out the specifick Difference that subsists between these three Sorts of Earth, we may consider them as so many Elements, perhaps, as simple and distinct, with regard to us, as the Salt, the Fire, and the Air ; and, whatever be their inward Structure, and the particular Configuration of their Parts, it is certain, that the great Author of Nature did from the Beginning create them such as they are at present, and has distributed them over the whole Globe, so as to form (by their uniting together, or mixing with other Matters) that prodigious Variety of Bodies and Productions, in which Man finds both the Necessaries and Comforts of Life.

The Use of
Sands.

The several Sorts of Sand have been distributed throughout the Earth, both upon and within its Surface, to procure us those numberless Advantages which arise from their different Quantities, Hardness, and Colours. And in the first Place, they serve as so many Store-houses of Water, which they keep in those intermediate Spaces between their Grains, to feed the Wells and Fountains. Without these convenient Receptacles, the Water would either sink too deep into the loamy, porous Earth, which would choke up its Passage ; or else by falling down on the more compacted Layers of Clay, which it cannot penetrate, it would issue out all at once, and, instead of supplying us with a constant gentle Stream, overflow our Lands and Houses. Nor is the Sand of less Use to

In Agriculture.

keep the best Soils from hardening and consolidating too much, which it does by separating those Parts which have the greatest Tenacity. Thus, though barren
itself,

itself, does it render other Lands fruitful, when rightly mixed with them, making them light and wieldy, and by its irregular Angles opening a free Entrance to the Water, and those fructifying Juices which it conveys into the Substance of Vegetables.

In Masonry. By an Effect no less surprizing than the former, this loose, incoherent Matter, so incapable of itself to unite and coalesce, is the very Cement which binds and holds together the Bricks, the Stones, and Marble, of which our Houses are built. All these Materials, however hard in themselves, would by little and little start out of their Places, and fall down in one promiscuous Ruin, were they not laid level, and cemented together by some tenacious Matter to keep them fixed and permanent in their Places. Now the Firmness and Stability of our Bridges, our Aqueducts and our Edifices, both great and small, is owing to a Mixture of Sand and Earth called Lime. Sand and Loam constitute the common Mortar, which is not so durable. The Lime, which is a loamy Earth hardened into a Stone and reduced to a Powder by Fire, does so exactly fill all the Interstices of the Sand, and so closely bind together all the Grains in one consistent Aggregate, as to compose a Mass, which in time acquires the Hardness of a Stone, and cements other Bodies with equal Firmness. Instead of Sand may be used Brick or Tile ground small, which makes a very strong Cement. The Reason is obvious: The Particles of Tiles and Bricks reduced to Powder have all the Hardness and Asperities of Sand, and are more porous, and consequently give free Admittance to the small Particles of the Lime to fix the whole with a greater Degree of Tenacity. This Composition, which is at first rendered so soft and pliable by the Water, as to spread under the Stone, and yield to the Pressure of the Workman's Hand, does in time dry and harden in the Air, which by Degrees exhausts the Water out of the Mortar, and in its room injects into it a great Number of Salts, which in Process of Time cause it to petrify, The extreme Hardness of the Cement in those Edifices which are the Remains of Antiquity, is nothing but the Work of the Air, and the Duration of Ages. We are

indeed apt to imagine that the *Greeks* and *Romans* were Masters of a particular Art in tempering their Mortar, which is now lost; but we may judge by the Hardness of the Mortar used in such of our Buildings as are two or three hundred Years old, that we shall in the same manner be thought by Posterity to have been possessed of a Secret in Building, which they will lament the Loss of.

It is the Sand also that gives that Coherence and Tenacity to Earthen or Pottery-Ware. You know that they make this sort of Ware of a fat ductile Clay, which, when it comes to dry in the Sun, or in a Furnace, and the Water to evaporate from it, decreases in Bulk, the Parts coming to closer Contact with each other; this necessarily causes Cracks and Fissures in the Vessel, which render it useless. Now this can be prevented by nothing but the Use of Sand, which, being thoroughly mixed with the Clay, so tempers and binds the whole Mass together as to make it impervious by Water, or any other Liquor.

In making Canals, and other Works.

The same Hardness of the Sand renders it likewise fit for making Canals or Trenches for the Conveyance of Water, as also Cisterns and Reservoirs for keeping it. Clay alone is apt to shrink in the Wet, and to chap in the Heap; whereas natural Sand, or Brick or Glass pulverized, together with Clay, make a Composition of a lasting, impenetrable Nature.

This same Property of Sand is also of Use in sawing Stones and Marbles, in polishing the hardest Bodies, in giving a Lustre to the dullest, and in making, polishing, and cutting Glass. It serves, by the Variety of its Colours, to enamel the Borders of our Parterres, as by its natural Dryness it procures us the Pleasure of walking in all Weathers, whether we chuse the Alley or the Terras, the Water quickly draining through the Gravel, which is not the Case in a spongy fat Earth.

The Earths, whether of a loamy or clayey Nature, which we find at different Depths under Ground, do so vary their Properties by being mixed with Sulphurs, Oils, and mineral Matters, as also by their different Preparations by the Fire and the Water, that we may consider the whole Earth as one great Laboratory, wherein that Omniscient Chymist, who only thoroughly understands the Principles of Nature, takes care to compound and modify them in such a manner as may best answer the several Wants of Man, for whose Use he first created them.

The Use of
different Earths.

In one Place you have Chalks, Ochres, Red-Lead, Boles of all Qualities for medicinal Uses, and of all Colours, either for sketching out the rough Draught and Plan of a Design, or for painting such Objects as may either give us Pleasure, or make useful Impressions on our Minds. In another are found different sorts of Marl so much esteemed by the Masons, for the excellent Chalk it produces, and

Marls.

still more by the Husbandmen, to whom, you know, it is an invaluable Treasure. In other Places are found metallick Earths, which we shall take Occasion to speak of when we come to speak on Metals. In many of our Provinces, but especially in *Lionnois*, *Auvergne*, *Burgundy*, *Hainault*, and also in *England*, they have inexhaustible Pits of a bituminous sort of Earth, which they call Sea-Coal, and which (by reason of its containing a great deal of Sulphur and Oil) is better than any other for softening Iron, and making it malleable. In *England*, and some other Places, it supplies the Place of Wood for Fuel. The Air of *London* is so impregnated with the sulphureous Spirits of the Sea-Coal, which is burnt in that City, that a Suit of Cloaths which has been worn there any Length of Time, will preserve the Smell of Sulphur for whole Years afterwards, though carried over Sea.

The other Vessels which fill the remaining Apartments in this Repository, contain, grey, green, white, and yellow Clays; some of them are simple, some mixed with Veins of other Earths: In different Places they have different Properties

Clay.

perties as well as Colours. One shall be good to stop Blood, and deserve, by way of Preference due to its sovereign Qualities, to be sold in little Cakes, stamped with an honourable Impression, to denote its Family, and to prevent Counterfeits. Another sort of Clay shall be good for cleansing Woolen-Cloth, and to imbibe all that Oil and Grease out of the Wool (as is practised in the Fulling-Mills) which was of such necessary Use in the combing and working of it; and such a Clay there is, which is almost as good for this Purpose as Soap itself. But let us pass on to the most excellent Use that Clay is put to.

The *Terra Sigillata* of Lemnos, Germany, Blois, &c.

Fullers-Earth.
Terra saponaria,
Smectica.

Models in burnt Earth.

Porcelaine.

Delft Ware.

This Earth is in the Hands of Man, what Man himself is in the Hands of God; it becomes under his plastick Hand, a *Vessel unto Honour or Dishonour* *. The Statuary moulds the supple Mass into a *Basso Relievo*, a human Figure, or, in short, into a Model of any thing he has an Idea of. It is afterwards committed to the Fire, which hardens it, and confers Duration on his Art.

The *Chinese* and *Japonefe* make of it that Porcelaine Ware, which has so long excited the Admiration and Emulation of the *Europeans*, but which is now so well imitated in *Holland*, at *Roan*, and *St. Cloud*, as greatly to sink the Price of this *Asiatick* Commodity.

There is another sort of Clay more common, of which they make the *Delft Ware*, which, on account of its extreme Neatness and Cheapness, is now in Fashion every-where. Whatever Pains the *English* and *Dutch* have taken to bring this Art to Perfection, I never yet saw any Patterns, either in the lesser or larger Works of this kind, that either for the Beauty of the Colours, or Prettiness of the Fancy, could come up to that which is made at the End of the Suburbs of *St. Severe* at *Roan* †.

* Rom. ix. 21.

† The Manufacture of *Delft Ware*, conducted by Madam de *Villeraie*.

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A Maker of Dutch-Ware at Work.

This Clay, which they work and fashion with as much Ease as the softest Paste, and which supplies us with so many bright convenient Vessels, is also very serviceable for other Uses, which, though in Appearance more mean and contemptible, are incomparably more valuable.

Chevalier. I perceive, Sir, you mean our common Potters Ware, which furnishes our Houses with all sorts of little earthen Utensils, which provides us with Bricks to build our Houses, where there is Scarcity of Stone, with Squares to pave them, and with Tiles to cover them. *Delft* Ware may serve for all these Uses, in the same manner that Procelane does in *Siam*, *Japan*, and *China*, as is attested by the concurrent Relations of several that have travelled into those Parts; in reading whose Accounts, I have been mightily delighted with representing to my Imagination their Walls, and the Tops of their Houses, so beautifully set off and coloured with this rich Earth. But tho' the Porcelane is very common in those Countries, yet this Piece of Magnificence can only be enjoyed by the Rich, the common People being very well contented with a more ordinary sort of Earth for their Vessels, and the Coverings of their Houses.

A few Days ago, I made a Visit to the Tile-Kiln, and the Potters Work-house, which are in the Neighbourhood, to see all the Particulars of their Art. Every thing at first Sight seemed to wear a dirty mean Aspect, but I was charmed with the Invention of the Wheel, with which the Potter turns his Ware so nimbly; and though the Structure of it is very simple, yet I cannot help looking upon it as one of the most useful Contrivances I ever saw, seeing it procures to three fourths of Mankind, the Convenience of eating their Meat in a cleanly, decent manner, and at a very little Expence. My honest Friend told me, as he was making his Pot, that if there were but a hundred Men in the World, ninety of them would eat off earthen Ware.

Prior. He could not have given a better Recommendation of his Art, than by setting forth the great Usefulness of it: Nor do I think it impossible to shew that this Calculation was just; but it may be sufficient to remark, that one half of the Inhabitants of Towns, and, generally speaking, all the Country People in all Nations
and

and Ages, have always used this sort of Ware, which never communicates any ill Taste or Quality to whatever is put in it.

Chevalier. It is very common for us, when we would denote any thing to be of little or no Value, to compare it to a Pot-shard, or earthen Platter; but however contemptible these Things may seem to some, I find they are of more real Advantage to us than even Silver or Gold itself.

Prior. This Clay, which is so universally serviceable to us, is to be found in almost every Country, and to be come at, for the most part, by digging a little way into the Ground. The Reason why Providence has made this sort of Earth so soft and ductile, and placed it everywhere so near at hand, is very obvious, seeing it is more necessary to us than the most precious Stones.

I might now entertain you with an Account of the many wonderful Effects and Properties of Loam; but I shall sum up its Character in three Words; *It feeds us* *: This is the highest Commendation of it that can be.

* And this it does mediately, by affording Nourishment to all sorts of Plants and Vegetables.

QUARRIES.

DIALOGUE XXV.

The PRIOR and CHEVALIER.

Chevalier. **I**T is with Reluctance I leave these Quarries which you have obliged me with the Sight of. All these great Beds of Stone, lying in Layers one upon another; the vast Quantities they have taken away from between these Props and Stays (which they have placed here to support the Vault above); the inexhaustible Stores that still remain; the Softness of the Stone, which makes it so easy to cut in the Quarry; and the surprizing Degree of Hardness that it acquires when exposed to the Air; all those Considerations fill me with Amazement. Had all the prodigious Masses of Stone that are under the Earth, been spread up and down on the Surface of it, we should not have had Room enough left for our Houses and Gardens; were they as hard in the Quarry as they prove afterwards, it would be endless Labour to dig and cut them; and were they to continue soft in the open Air, we should not be secure in our own Houses. How carefully and wisely has Providence ordered every thing for our greatest Use and Convenience!

Prior. Your Admiration and Gratitude would be still increased, were we to take a View of all the different sorts of Stone that are deposited in those vast Store-houses under our Feet, and to consider the different Ends and Uses, for which they were appointed.

Chevalier.

Chevalier. Are not all Stones then of the same Nature? And are they not the respective Degrees of their Hardness, that alone make the Difference betwixt them?

Prior. Your Question, my dear Chevalier, opens a large Field for Inquiry, and useful Conversation: But let us quit these subterraneous Regions, lest you should receive any Injury from the Damps, and ascend up to the Mouth of the Quarry: Those Stones will serve us for Seats. We will, if you please, proceed methodically, discoursing first on the different sorts of

The Division of this Discourse.

Stones that we are acquainted with; next, on the Manner how they are formed beneath in the Earth; and lastly, on the

Usefulness of them.

The different sorts of Stones.

Stones in general are of two sorts, precious and common Stones. Precious Stones are either transparent or opaque; and they are valued for their Lustre, their Colour, their Smoothness, or their Weight; as to those medicinal Virtues and miraculous Qualities which have been ascribed to them, they are nothing else but the Effects of Fancy or Credulity.

The Diamond.

Of all transparent Stones, the Diamond is both the hardest and most beautiful; all the other Stones lay claim to the second Place, and are preferred as the Fashion, or the particular Fancy of People, gives them the Precedency; the Diamond only remains unrivaled in the first Place, by the universal Consent of all Ages and Nations.

The Excellence of this Stone consists in its Hardness, Weight, and fine Water.

Chevalier. Its Hardness, by Relation, is so great as to be Proof against the violent Blows of a Hammer. Pray, is not this Power of Resistance, as imaginary as those medicinal Virtues, that are ascribed to the Diamond?

Prior. Two Travellers one Day disputing on this Point, after a great many frivolous Arguments, he that maintained the negative Side of the Question, said to the other; I will go with you to a Lapidary, and stake my Diamond against your's, that he breaks with his Hammer as many Diamonds as you will stand to the Loss of.

The

The other did not care to run the Risque, and so the Dispute ended.

Chevalier. Pray, Sir, what is meant by a Carat Weight so often mentioned in speaking of Diamonds?

Prior. It has a very different Signification from the Word Carat, when used in speaking of Gold. The Mark or Half-pound Weight of Gold, is divided into

A Carat in Jewels.

24 Carats, of which there are seldom above 22 of pure Gold, the remaining two consisting of Silver, or some other Allay; the Carat is further divided into 8 Penny-weights, and each Penny-weight into 24 Grains: Whereas a Carat in Jewels weighs but 4 Grains, and those not so heavy as the Grains in Avoirdupois Weight.

The heaviest Diamonds that we have any Knowledge of, are, that belonging to the King of *France*, weighing 106 Carats; that of the Grand Duke of *Tuscany*, weighing 139 $\frac{1}{2}$; and that of the Great Mogul, weighing 279. Mr. *Tavernier* valued the last at above eleven Millions of Money, and the two others in Proportion.

Chevalier. By the fine Water of a Diamond, I know they mean its Clearness; but pray why do they give it that Name?

Prior. Because a Diamond should be clear and pellucid as Water is, and, like it, without any Colour.

* One of the surest Ways of distinguishing betwixt real and counterfeit Diamonds, is that Property which the former has of sticking closely to black Mastick, upon which they set them, in order to give them a greater Lustre. As to the Manner of cutting rough Diamonds, whether Brilliant, Bezil, or Table-wise, it is a very curious Art, and which you can only have a Notion of by seeing how they perform it.

Next to the Diamond, the Ruby generally succeeds, in Degree of Esteem: If it is of a Crimson-colour with a Cast of Purple, it is called the Balas-Ruby †; if of a bright rosy Red, it is called the Spinel-Ruby ‡. These Names probably are derived from the Language of those *Asiatick*

The Ruby.

* *Boet. Gemm. Histor.*

† See *Woodward*, on Fossils, p. 29.

‡ *Ibid.*

Provinces where those Rubies are found. If the Spinel-Ruby be of a rich Blood-red Colour, and weighs about 20 Carats, it is called a Carbuncle: As

The Carbuncle. to what is said of this Stone's shining in the Dark, no manner of Credit is to be given to it; for as it shines with greatest Lustre in the strongest Light, so has it none but what it derives from it.

The Garnet. The Garnet partakes of the red and flame Colour of the Ruby, and is perhaps of the very same Species with it.

The Hyacinth. The Hyacinth, which is sometimes of a deep Red, like the *Bohemian* Garnet, sometimes of a yellow, orange, marygold, or amber Colour, when pulverized and mixed with the Powder of other precious Stones and Drugs, makes one Ingredient in that Preparation which we call Confection of Hyacinth: This has the Reputation of being an excellent Medicine, though, if we set aside the

Confection of Hyacinth. Name, and the extravagant Price it formerly bore upon that account, perhaps the Hyacinth will be found to have very little, if any, Share in the Merit of this Composition.

The Amethyst. The Amethyst is of a bright Purple, bordering upon Red. The Emerald is of a bright Grass Green. The Beryl inclines to a Sea or bluish Green. The Sapphire is of a Sky-blue. The Topaz or Chrysolite is of a Gold Colour. The Opal seems possessed of the different Beauties and Colours of all the other Stones.

Of transparent Stones the Crystal is most common, some of which are found in *Alençon* and *Medoc*, which come very near the Diamond. Of Stones that are entirely opaque, or only half transparent, the Sardine or Carnelian is most esteemed. This Stone is of a flesh Colour, or very

Carnelian. * The Cat's Eye is a kind of Opal. There is also another sort of Cat's Eye which is not transparent.

pale Red, sometimes bordering upon Orange. The others of this Sort are the Onyx, which is of a greyish Cast, or a Mixture of black and white; the Turquoise, which sometimes inclines to Blue, sometimes to Green; the Lapis Lazuli, which is studded with Spots of Gold on an Azure Ground; the Aventurine, which has the same Speckles on a Ground of Musk or Coffee Colour. But all these, with many other Stones, might be ranked under the Classes of Agate and Jasper, which probably are Stones of the same Nature; only the Agate is a little more transparent, harder, and will take a finer Polish: Both the Agate and Jasper vary their Colours without End. On these Stones we sometimes find the first Draughts or Sketches of Flowers, Trees, and other natural Figures, which are easily perfected by the Help of Art.

Onyx.

Turquoise.

Lapis Lazuli.

Agate.

Jasper.

Figur'd Stones.

Chevalier. I have seen some Stones of the common sort, which were naturally figured, and wherein one might plainly trace the exact Shape of several Plants that are well known among us, and sometimes of such as are only to be found in *China* or *Peru*.

Prior. I shall come presently to give you my Opinion on the Formation both of these and all other Stones; but let us first make an End of our Catalogue. And next for common Stones.

The Stone for Building with is that which we have the most Acquaintance with, and is the most diversified of all, there being several sorts of it, as soft, hard, smooth, rough, &c. The different sorts of this Stone vary their Grain and Colour, not only in different Countries, but even in the different Strata of the same Quarry. The other common Stones are the sandy or brown Free-stone, the Lime-stone, which is easily calcin'd, the Whet-stone, which is a sort of brown Free-stone, and the Flint which can never be cut quite smooth, and which emits Sparks of Fire when struck

Stone for Building.

Brown Free-stone.

Flint.

struck against another Stone of the same sort, or a Piece of Steel.

There are some which consist of small Filaments or Fibres adhering close together; such is the feathered Alum, as also the different sorts of Amianthus, the Threads of which they have the Art of Spinning and Weaving into the

Asbestos, which is a kind of Cloth that is Proof against the Force of Fire. The Pumice-stone,

Pumice-Stone. which is so light as to swim on the Top of Liquors, and is used by many Artizans in their several Trades, is much like a Mass of Amianthus thoroughly dried. There are also Stones which are composed of thin *Laminae* or Plates, lying close one upon another; of this sort is that Stone, of which Plaster or Parget is made; such also is the Slate, and all the different Kinds of Talcs which you may split into Plates or Leaves to what Degree of Thinness you please, and which are used, on account of their Transparency, to put before Pictures in Miniature and Pastel, through which they appear as clear as through so much Glass.

The most noble and magnificent of all common Stones is the Marble, of which there are several sorts; the white, the black, the *Ethiopian* black Marble or Basaltes, the *Ly-dian* black Marble, (which is the Touch-stone used by the Goldsmiths) the green Marble, the Granite, which is extremely hard, and full of green and white Spots, the Porphyry, which is no less valuable for its extreme Hardness, than its beautiful red Colour, and, in short, Marbles vein'd with all sorts of Colours.

The Alabaster, both white and vein'd, is likewise a sort of Marble, and only differs from the others in that it is more soft and easy to cut. But it would be endless Labour to undertake a particular Account of all the subordinate kinds of Stones, seeing they are without Number.

Chevalier. I am very impatient to learn how a Flint, a Diamond, or a Block of Marble, is formed in the Earth.

Prior. There are three different ways of Petrification that we are acquainted with, which being easily observable and conceivable by us, may assist us in making a pretty exact Discovery how all others are performed. The Origin of Stones.

Of the first Kind is the Stalactites, or that cylindrical Congelation which is formed in the Shape of an Icicle in the perpendicular Fissures of Vaults and Caverns, out of the sparry, sandy, and other Matter that is drained out of the Strata by the Water passing through them into those Fissures * ; and these do gradually increase in Proportion as they are covered with fresh Coats of the same Matter.

Of the second sort of Petrification are those Crusts of Stone which the Water of certain Springs leaves sticking to the Pipes it passes through, as is observable in those which convey the Water from *Rongis* and *Arcueil* to *Paris*. Now it is very plain that this petrified Matter, of what Nature soever it be, is impelled by the Water towards the Sides of the Pipe : The Reason of its incrustating in irregular Lumps or Clods one upon another, is the irregular Action of the Water upon this stony Matter, which it casts sideways from the Centre of its Course, to force itself a free Passage.

Of the third kind of Petrification that we are thoroughly acquainted with, are those Pieces of Wood, Shells, and other Substances, which are found petrified under Ground, or in certain Fountains, still retaining their natural Figure and Lineaments. Now the Manner in which these three different Petrifications are performed, we will suppose to be thus ; the first by thin Leaves or Teguments ; the second by little Lumps ; the third by Infertion.

Chevalier. I think I understand your Division pretty well. But pray, what are those different sorts of Matter which apply their Surfaces to each other in the Form of Leaves, or those which adhere together in little Lumps ; or lastly, which insinuate themselves into the Pores of another Body ?

* See *Woodward* on Fossils, p. 18.

Petrification by
Leaves.

Prior. We have no Acquaintance with any other Elements than those I have mentioned to you, *viz.* Water, Salt, oil, Juices, Sand, Loam, and Clay *. The Water itself is no Ingredient in the Composition of Stones, but is only that which brings together and mixes the Materials of which they are composed. The natural Formation of Stones is perform'd nearly in the same manner with the artificial Structure of Houses, in which the Water serves to unite and fix the Materials, after which they harden and consolidate as the Water dissipates. Our Walls are composed of hard Masses of Matter and Cement; the Cement of itself would never form a durable firm Wall, and the Masses, whether of Brick or Stone, laid one upon another without any Mortar between them, would easily be shaken down; whereas the Interposition of the Cement produces these two Effects; first, by filling up the Interstices between the Masses, it keeps them fix'd in their Places; and secondly, by insinuating itself into the Pores of those Masses, it incorporates with them, so as to constitute, when thoroughly dry, one entire, compacted Body. So likewise our three different ways of Petrification are perform'd by little Masses, and a very fine Cement: The Masses to be joined together are the Sand, the Clay, and the Loam; the strongest Cements are the Salts, and the different sorts of Bitumen. Sometimes the Salt and Clay serve as a Cement to the Sand; sometimes either the Clay or Loam does of itself constitute the Mass, and from the different Quantities and Proportions of these Matters differently mix'd together, results an almost infinite Variety of Productions; but then it is the Water that performs all the several Offices of collecting, conveying, and associating all the different Particles of Matter, which afterwards condense into Aggregates of a hard durable Nature.

Under the first kind of Petrification may be ranged the Talcs, Slates, the Amianthus, and Plaister.

* Our Author here only speaks of those first Principles which constitute such Bodies as are the Object of Chymistry, and into which they are reducible by it.

Crystal is nothing else but an Aggregate of Sands, either of a pyramidal or triangular Figure, which the Water incrustates successively upon one another, by a Cement of Salt and very fine loamy Earth : And this appears the more probable, for that when Crystal is resolved by Fire into its constituent Parts, we can discover nothing but a calcin'd Sand together with a little Earth and Salt. Nor is it at all to be wonder'd at, that such a beautiful transparent Mass should be form'd out of Sand, seeing the Particles of the Sand itself, when viewed through a Microscope, appear like so many pellucid Crystals : The Reason of their not being bright and clear in their natural State, like the Diamond, is because of the Earth that is mixed with them.

It is no hard Matter to conceive how a Column of Water, in the Course of its Descent, may lodge in any certain Place a *Lamina* or thin Plate of Sand and blackish Earth ; and how another Column may deposit another Plate of the same Matter on the former, and by that means, in time, form Slates of a different Thickness.

From such-like Layers of various Kinds of Matter are formed Talc, Amianthus, and Plaister.

Chevalier. Pray, Sir, how comes the Amianthus to be able to resist the Power of Fire ; and by what peculiar inherent Property does Plaister, when pulverized and moistened, contract immediately so great a Degree of Hardness ?

Prior. Were the Amianthus chiefly composed of Fibres, or thin Layers of Clay, we might easily account for its being incombustible ; but to deal ingenuously with you, I must confess that I am ignorant, both as to the Matter and the Structure of the Amianthus : However, I may venture at an Explanation of the Stone of which Plaister is made :

And herein the Sand with a Mixture of Loam seems to be the predominant Principle. This Stone is easily resolved by a gentle Fire, which separates the loamy Particles from the Sand, and reduces them to Powder. The Reason why the Plaister, when mixed up with Water, hardens immediately into a firm consistent Body, is because the Water conveys into the Pores of the Sand (which retain their original Form) the little loamy Particles calcin'd by the Fire, which

like so many fine Sponges immediately imbibe the little Quantity of Water pour'd upon the Heap, which causes them to swell till they exactly fill all the Interstices of the Sand, and constitute one solid compacted Mass, in which the Water is wholly absorb'd. These little spongy Masses, which are form'd like so many Pipes, preserve their Figure without shrinking, and keep, by that means, the several Grains of Sand in close Combination, notwithstanding the gradual Evaporation of the Water from within them.

You may remember, Sir, that we remark'd in a former Discourse *, speaking on the Formation of the Shells of Shell-Fish, that they were nothing but a Collection of several Pellicies successively formed one within another, by the different Transpirations of Matter from the Body of the Animal within: This same Accumulation of Plates or *Lamine* upon one another, so visible in certain Stones, has given Occasion to that Mistake of some Naturalists, in other respects very famous and judicious Men, that Stones have a Bud or Shoot like Plants, and grow by a sort of Vegetation.

Grumeus Pe-
trification.

The second kind of Petrification is that which is performed by little grumous Particles, singly or in Clusters; and probably all precious Stones are formed in this manner. They are found, for the most part, pretty deep in the Fissures and Cavities of certain Rocks, whither the Water can scarcely convey any other Matter besides Sand, Salts, some Drops of Bitumen, and now and then some metallick Particles. These little Lumps or Globules of Matter, when they come to coalesce and harden, form themselves into Stones of different Grains or Textures; opake, for Example, when the Clay or Loam is predominant; spotted or veined with Gold or Silver, as Particles of these Metals happen to mix with them; and lastly, transparent, when the Bitumen or finest Sulphur, with a Mixture of Salt, cements together such Grains of Sand as are pure, brilliant, and uniform. When the Angles of the Sands are so situated, with respect to each other, that their flat Surfaces lie together in close Contact, and the finest Grains exactly fill up the Interstices of the larger; in this Case the Stone which is formed out of

* Part I. Dial. IX.

these Sands is without any Imperfection ; whereas, if the Angles of some Grains are so inclined to the plain Surfaces of others as to leave any void Place betwixt them, this Vacancy becomes a Defect or Flaw in the Stone, which lessens the Value of it ; and this suffers still a greater Diminution, when there happens to be an Admixture of any extraneous Matter in the Sand.

Flaws in Diamonds.

Every sort of Sand is not of the white crystal kind ; for by the Help of a Microscope we may discern some to be of a green, some of a red Colour : And this perhaps is the first principal Cause of that Diversity of Colours which we find in precious Stones. The Honourable Mr. Boyle * remarks, out of a very famous Traveller, that in the Mines of *Visapour*, and of other Places, the Diamonds are found partly betwixt two Rocks, partly on a Bed of Earth ; that those which are taken from betwixt the Rocks are of a pure Water without any Colour, but that the others partake of the Nature of those Earths where they are formed ; that if the Sand is pure, and only of one Colour, the Diamond is the same ; but that if the Sand is mixed, the Diamond does incline to Black, Red, &c. according to the Nature of the Sand. To the Diversity of Sands let us add also the different Tinctures, whether bituminous, vitriolous, or metallick, which enter into the Composition of Stones ; and this will furnish us with another Reason why the same Colour is fainter or stronger in different Stones, and why different Colours are sometimes united in the same Stone.

Chevalier. What convinces me that Bitumen is one Ingredient in the composition of these little Crystals, as well as in that of Amber and Jet, is, that several Stones have the same Quality of attracting little Straws, and other light Bodies. But pray, Sir, is it possible to explain the Manner how this Attraction is performed ?

The Electricity of several Stones.

Prior. I will venture to give the following Conjecture as a probable Solution of this Phænomenon. Bitumen

* *De Gemmarum Origine.*

abounds with fiery Particles shut up within the Pores of this Matter : Now upon rubbing any Body wherein these little Corpuscles of Fire are imprisoned, we thereby set them at Liberty ; the immediate Consequence of which is their causing a Rarefaction in the contiguous Air, which, compressing the Air that is more remote, causes it to exert its elastick Force, and to repel the rarefied Air back to the electrical Body, carrying with it to the Centre of its Motion all those little light Substances which it meets with.

Flints.

The Formation of Flints, and other irregular hard Stones, seems to be the same with that of precious Stones. The Water in its Passage over *Strata* of Marl, Chalk, Clay, or Rock, finds Cavities of different Sizes, in which it deposits the Salts, Oils, and fine Sands, of which it is the Vehicle ; the Water afterwards evaporating, the Sand and other Matter which it lodged in these Cavities, hardens as in a Mould, and assumes the same Figure with the Cavity, in which it is cast. When a fine sort of Sand predominates, the Stone is proportionably transparent, and has a fine sharp Edge, as is the Case in most of your precious Stones ; its Colours are more or less vivid, variegated, or veined, according to the Proportion of the other Matters that are commixed with it. If there happens to be a great Proportion of Salt or Sulphur in the Composition, which, you know, are Substances that yield a strong Smell, and abound with Fire ; the Stone when broken will send forth a sulphurous Stench, as also emit Sparks of Fire, if struck by another Flint of the same Hardness, or a Piece of Steel, the Force of Percussion breaking open those little Cells in which the Particles of Fire are lodged, and thereby setting them at Liberty. The Reason why these Stones have no Electricity, is because the Corpuscles of Fire which they contain, are enveloped with earthy Particles, which weaken the Force of Friction, just as a Lift of Woollen applied to a Glass, or the String of an Instrument, interrupts the Vibration, and stops the Sound.

There

There are great Numbers of Flints of all Sizes, some round, some oval, some approaching near to these Figures, which seem to have been formed in little Balls, or by thin Incrustations round a Kernel which served as a Base for this Superstructure. For Example :

The Water, by frequently passing over a Round Flints. little Mass of Mortar, Marl, or Stone, fills up all the Inequalities that are in it, with those little loamy Particles with which it is charged, thereby making it to have a smooth and nearly regular Surface. The Kernel being thus formed, the Water at different times invests it with several Coats or Coverings of Sand, which harden round the Kernel at the Centre of the Mass as the Water evaporates ; the Bulk of the Stone continuing its Increase, in Proportion to the Number of Layers or fresh Coats of Matter successively formed round it by the Return of the Water. Now it may so happen, that the Kernel of Chalk, Marl, Stone, or common Earth, which served as a Basis to the first Crust or Coat, being penetrated by a very intense Heat, may send out all its Humidity by Transpiration, and contract itself into a lesser Compass ; which may be the Reason why we sometimes find a Cavity in the middle of a Flint, and sometimes within that Cavity, Chalk, common Earth, or a Substance of a quite different Nature from the Flint itself ; and lastly, why upon shaking a Flint we sometimes hear a hard Body rattle within it. Thus we see that the Formation of round and oval Flints is nearly the same with that of certain Stones, called Bezoar Stones, which are found in the Bellies of several Animals in the *Indies*, and to which are ascribed many rare Virtues.

Chevalier. These different Crusts, this Cavity in the middle, and this hard Body that rattles within it, are always to be found in a sort of Flint, which I have often seen, and which they call the Eagle-Stone ; though, if it be formed in the The Eagle-Stone. manner you describe, I much question whether it has any Properties superior to those of the common Flint ; for by your Hypothesis you entirely rob it of all its boasted Virtues.

Prior. I rob it of none but what were falsely ascribed to it. But let us proceed to the last kind of Petrification,

which is performed by Penetration or Insertion ; and this is the most common.

The Formation
of Stones by Penetration.

A large Bed of Sand, Clay, or other Matter, may be petrified by the Injection of those Salts and small Particles of Earth which the Water collects in its Passage ; and though the Water with all the Salts that are in it will pass through a Body of Gravel, or Sand, which is too porous to separate the latter from the former, yet it will insinuate its Salts into the Pores of a more compact Body, and link all the Parts of it closely together. By these means a Bed of fine Sand shall be transformed into a Mass of brown Free-stone ; and a Bed of Earth and Sand together, shall be changed into a Stone more or less hard, according to the Proportion that these two different Bodies bear to each other in the Composition.

Marl and Clay mixed with Sand will convert into Marble, the Ground of which shall be white, red, green, or black, according to the Nature of the petrified *Stratum*. The *Subjectum* or Basis of Marble is perhaps, for the most part, nothing else but a Body of very fine Sand, into the Pores of which the Water has insinuated, at different times, little Sediments of Marl and Clay, which in Process of Time unite into one hard compact Body, and constitute Marbles of different Kinds, Colours, Mixtures, and Shades. If the Clay happens to be the first *Stratum* or Basis, and is dried and chapped by some subterraneous Heat, the Particles of fine Sand, Marl, or other Matter, which the Water deposits in these Fissures, will form in it Veins of all Colours and Shapes. This Variety of Colours is also farther embellished with little Spangles of Gold, or some other Metal fine enough to be carried thither by the Water. The Drops of Oil that are intermixed with the aqueous Globules, spread themselves into that vast Number of little Spots which we discern in Marble ; when they have free Liberty to diffuse themselves, they become round Spots, oval when they are attracted side-ways by others, and angular or of any other Figure, according to the different Obstructions or Attractions they happen to meet with. All these little irregular winding Veins, which we sometimes see studded with Specks

Specks of Gold, or some other inexpressibly fine Grains of Matter, are so many Foot-steps, whereby we may distinctly trace all the different Routs, Turnings, and Advances of the Water through the Body of the Stone, leaving, as it goes along, those various kinds of Matter of which it is the Vehicle, which being specifically heavier than it, naturally subside and lodge in the first Pores or Cavities they find fit to receive them. The Formation of Marble or Stone may not unaptly be compared to the weaving a Piece of Cloth or Tapestry. The *Stratum* of Sand or Loam, which is penetrated by the Water, is, as it were, the Warp of the Work; the Water is the Shuttle that passes through it; the fine Sands, the Sediments of the Loam, the Particles of the Clay, and the small Threads or Fibres of metallick Bodies, are, singly or collectively, the Woof which is introduced by the Shuttle, into the Warp or Body of the Work, and which fills it up by Degrees.

Chevalier. I believe I pretty well understand the Explanation of this Phænomenon: But I remember, when we were in the Quarry, you made me observe how betwixt the different Beds of Stone, there was a thin Layer of pure unmixed Clay; and you added, that these Layers of Clay were almost always found betwixt large *Strata* of petrified Matter. Now how comes it to pass, that these intermediate Layers of Clay escape Petrification, whilst the Bodies both above and below them harden into Stone?

Prior. The pure Clay, instead of being penetrated by the Water, serves as a Basis or Bottom for it to rest on.

Chevalier. I will readily grant you, that the Water may easily introduce various kinds of Matter into the Pores of a Body which lies upon the Clay, and thereby bring it to a State of Petrification; but if the Water does not penetrate and pass through the Clay, how can it petrify any *Stratum* beneath it?

Prior. The Water finds a Passage through many Chinks and Fissures in the Clay, or diffuses itself, and the petrifying Matter that it contains, over the Extremities of the Layer, and so descends into the inferior *Strata*. Don't you remember the *Stratum* of Rock in the Mountain of

Laon *, which, notwithstanding its prodigious Thickness, does not hinder the Water from passing into the Bed of Sand which is far beneath it ?

What the Water performs in great, by insinuating itself into the different *Strata* of Matter, that are extended under the Earth, it performs in Miniature in Pieces of Wood, Ivory, Bone, and other Matter, which it penetrates ; nor can we, by any other way, account for several Petrifications of a very extraordinary kind, which are found in all Parts of the World.

Whether there was at the Deluge an universal Earthquake, which changed the Form of the Earth, by exalting the lower Places, which the Sea occupied before, and depressing the more elevated Parts, which were inhabited by Mankind ; or whether God only changed the Place of the Waters, by sinking that Part of the Globe, which was before inhabited by Men, to be a new Receptacle for the Ocean, and fixing our Abode where the great Deep was, we find by Experience, in all Places and Countries which are inhabited, as well in the smallest Islands as Continents, on the Mountains, as well as in the Plains and Quarries, undoubted Proofs that these Places were once covered by the Sea. However this Change wrought in the Earth by the Deluge (which must have been universal) was brought about, the Consequences which flowed from it, with regard to the Matter of Petrification, (which is the Subject of our Inquiry at present) are as follow :

Several marine Bodies of all sorts buried in this Menstruum of dissolved Earth, become petrified in time, by the Insinuation of the Waters, Salts, and other little crystalline or stony Particles so adapted to the Pores of these Bodies, as to fill them up without causing any Alteration in the Figure of the Bodies themselves : Hence were produced a Multitude of Stones, which, for the Singularity and Oddness of their Shapes, gave Occasion to fanciful People to look upon some of them as possessed of certain secret Charms and Virtues, and upon others as the Mimickry and wanton Productions of Nature.

Besides the Bones of Crocodiles, the Skeletons of Sea-Horses, and the entire Bodies of Fishes petrified, there are

* See p. 105.

found up and down in several Places, Shells of all sorts, and all the different Parts of Sea-Animals converted into Stone. Of these Bodies, some are surprizing for the Manner of their Situation, others for the Singularity of their Shape. But supposing, my dear Chevalier, such a Confusion of Substances all over the Earth, at the time of the Deluge, how shall we be able to account for all those Sea-Shells that are found in the Middle of our hardest Stones, nay even in the Heart of Marbles?

Chevalier. If these Shells, by any universal Agitation or Commotion of the Earth, happened to be deposited in certain *Strata* of Matter, which afterwards came to harden and petrify, it is not at all to be wondered at, that they should be found lodged in the middle of those Substances; nor is such a Situation of these Shells more strange than that of the Flints, which you just now shewed me in the Centre of some Stones, when we were at the Bottom of the Quarry. These Flints and those Shells subsisted before the Deluge; the Bodies that inclose them were petrified afterwards.

Prior. The Number of the petrified Sea-Bodies is too great, to give you an exact Catalogue of them; but in order to vary the Entertainment of your Walk, I have brought with me some of the smallest of them, as being most portable, by which you may judge of the rest. Here they are.

Chevalier. Pray what is this indented Triangle so curiously incased in a Circle of Silver? Is it some Amulet or Charm to hang about the Neck?

Prior. At *Malta*, where these Kinds of Stone are sold, they tell you, it is in the Shape of a Dart, or the Tongue of a Serpent, which was petrified at the time of *St. Paul's* Arrival in that Island, and, among other Virtues ascribed to it, has that of enriching the Goldsmiths: But here this Tongue loses both its Shape and rare Qualities. It is really nothing else but the Tooth of a great Sea-Dog or Shark *, which is a Monster of an enor-

The *Glossopetra*.

Canis Caribaeus.

* *Saggio d' Istoria medice naturale del Cavalier Vallisneri, Tom. 3. Edit. Fol.*

mous Size, weighing sometimes upwards of four thousand Pounds.

Chevalier. Here are some Stones that one would take for real Buttons.

Prior. These ribbed Buttons, and those others which you see there studded with little Tubercles regularly ranged, are Substances of a stony Nature, introduced into the Shells

of certain Fishes called *Echini*, or Button-Fishes. The chalky or other Matter

Echini. moulded in the Shell, retains the exact

Form of it; but the Crust of the Shell being extremely thin, is intirely decayed and perished.

Chevalier. What are these little Stones, which resemble a Cork-screw, or twisted Serpent?

The Horn of
Ammon *Cornu*
Ammonis.

Prior. They are Pieces of petrified Earth, formed in a little turbinated Shell of a spiral Figure, and which resemble the *Nautilus* or Sailor-Fish. The Matter which is hardened within the Shell, bears exactly the Impression of the Mould in which it was cast; but the Shell itself being extremely fine and tender, is consumed and reduced to Powder. The antient People of *Libya*, who thought that they discerned upon this Stone the Horn of their Ram *Ammon*, which, you know, was their favourite Deity, related a hundred Stories of the Virtue of this Stone, which gained it a great Reputation, and gave it the Name of *Cornu Ammonis*.

Chevalier. But if Philosophy strips these Stones of all their Virtues, have not we Reason to complain that we are Losers by it?

Prior. It sometimes proves the Means of enriching us, by helping us to the Discovery of those real Virtues, which are inherent in Bodies; but it can no ways be said to impoverish us, by shewing us the Fallacy of pretended ones, and thereby preventing our being imposed upon.

Chevalier. What other Stone is that, which in Shape so much resembles a Finger, but only is longer and more pointed?

Prior. There are some of them of a larger Size; I took this as being more portable. They formerly took it for the Thunder-

D. & Y. l.

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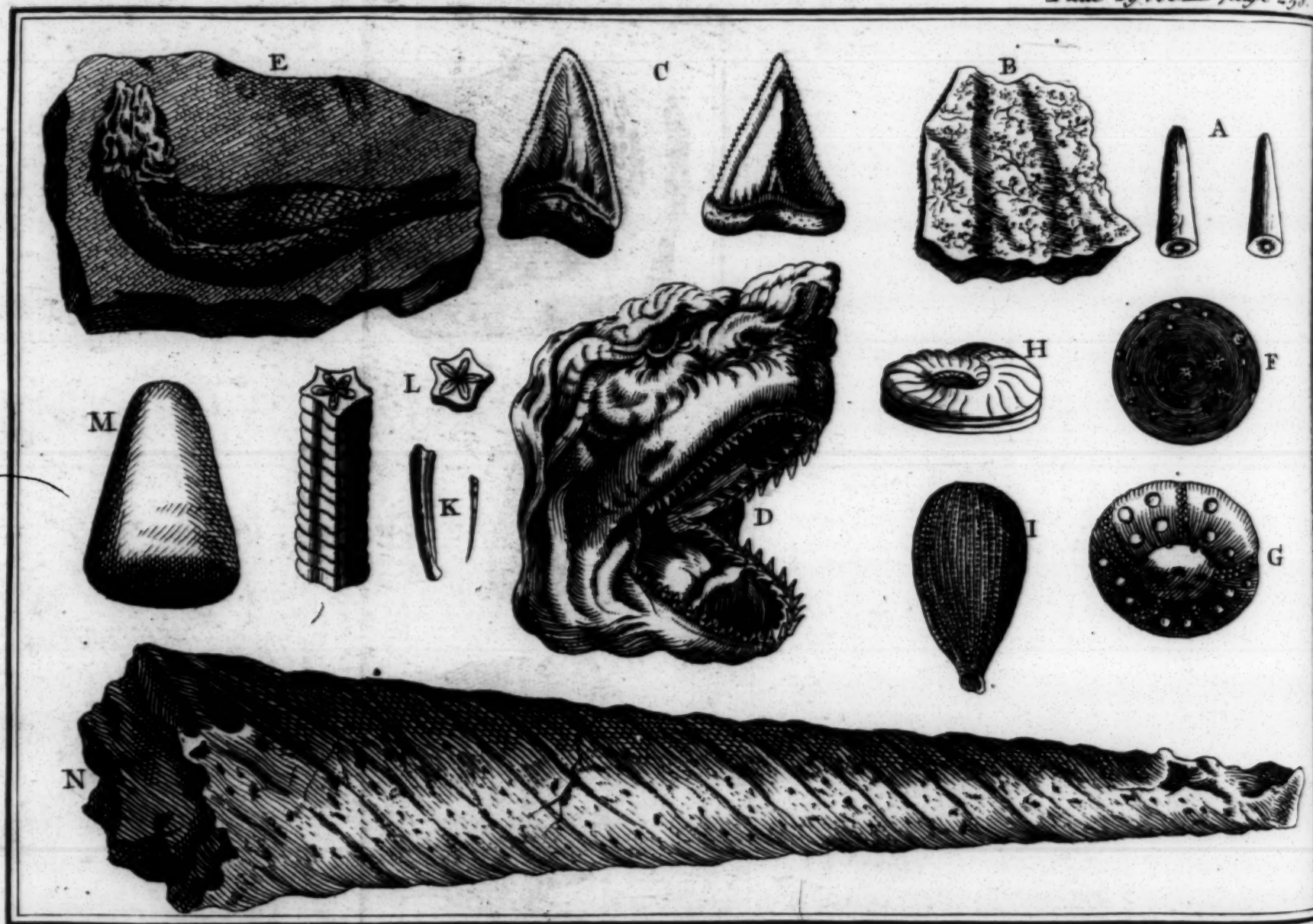
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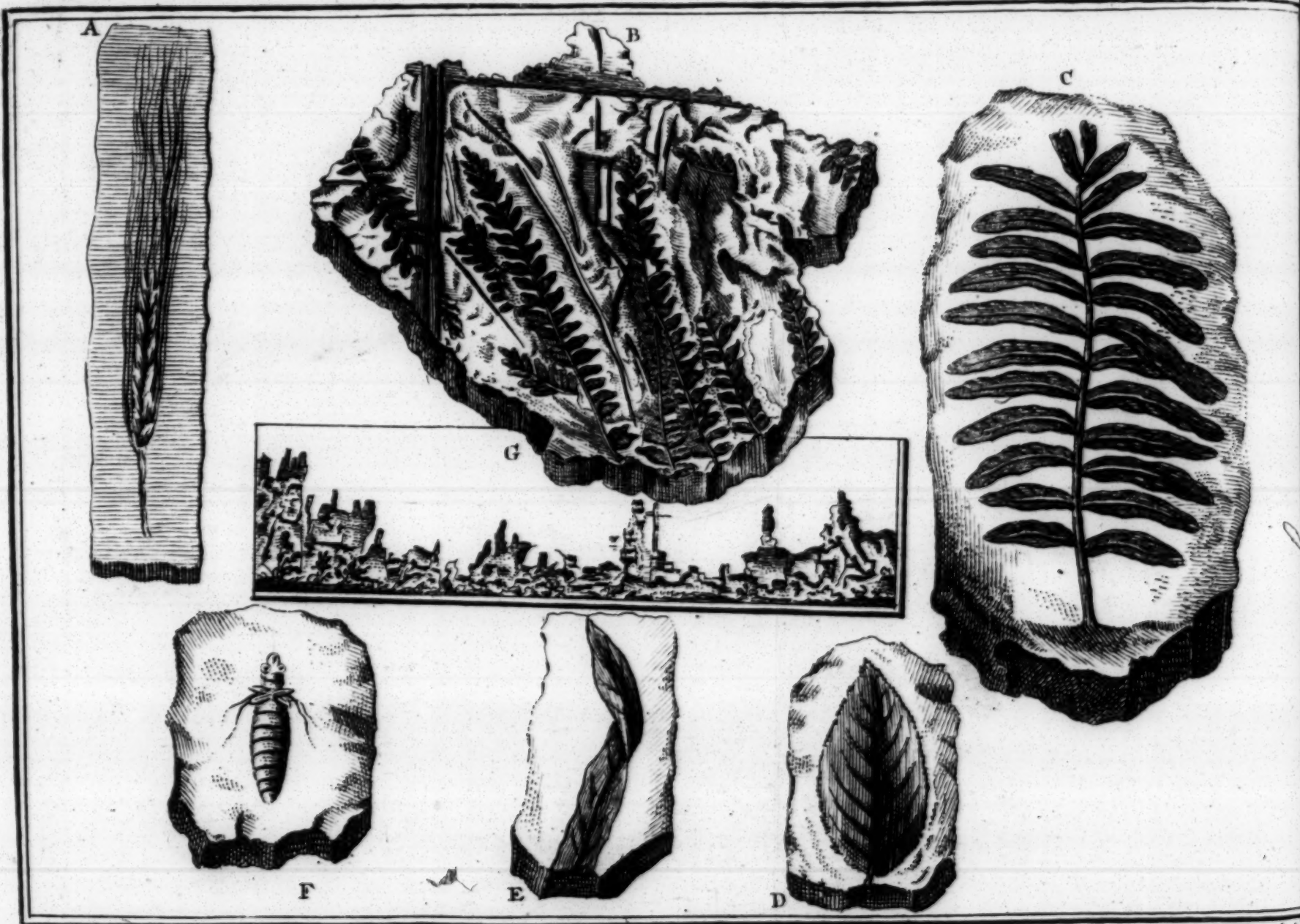
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Petrified Bodies.

Wm. J. S. J.



Figured Stones —

Time July

Thunderbolt: You see what Connection there is betwixt Fire and a Stone. At present there is no Doubt made of its being the Tooth of some great Fish, though no certain Discovery has yet been made of the Animal itself. It is not, probably, any of those which make their Abode on our Coasts, and this Conjecture is warranted by the Instance of the *Cornu Ammonis*, of which we have a hundred several Sorts, all differing in some respect or other from the *Nautilus*, that we are acquainted with. The other Species of the *Nautili*, or Shell-Fish, of nearly the same Figure with them, do probably live on other Coasts, or else at the Bottom of the Sea.

Thunderbolts.

Betyls.

The Belemnites.

Here are other Stones, which are convex at top, and concave underneath. They much resemble the Teeth of the Sea-Wolf, and the beautiful Polish of these Stones is nothing else but the Enamel which formerly covered the Tooth of that Animal.

Toad-stones.

Chevalier. Here are some others, on which, methinks, some Artist, to divert himself, has painted a Star, a Fish, or the Leaf of a Plant.

Prior. These are indeed, as you say, Pictures, and true Copies of Nature. This Stone, in which you see so just a Representation of a Star, is a Mass of Earth, stamp't with the Impression of a certain Shell-Fish, called the Sea-Star, if it is not the very Fish itself, petrified together with the Earth, to which it adhered. There are several sorts of them, which bear a respective Similitude to the different kinds of this Fish. Some of these petrified Bodies immersed in Vinegar, seem to move and stir about; the Reason of which Appearance is this: The Points of the Acid which constitutes the Vinegar, by insinuating themselves into the Pores of the Stone, make way for the Introduction of a warmer Air, than that which was lodged therein before; which being immediately dilated, and struggling to disengage itself, surprizes the Spectator with that tremulous Motion it causes in the Stone. Some of these Star-Stones are regularly applied one to another, with

The Astroites or Star-stones.

their flat Surfaces together, and resemble the *Vertebra*, or Joints in the Back-Bone of a Cod-Fish.

Chevalier. Perhaps they may be nothing else but the Back-Bone of some other Fish.

Prior. Here are two or three other Stones, which present you with Plants in their perfect Shape and Proportion, on a smooth flat Surface; for the Juices that agglutinated the Plant to the Stone, did so thoroughly penetrate into the Substance of it, as to incorporate them both into one Body, only preserving the Lineaments and Figure of the Plant. This here is a natural Picture of an Ear of Barley; that of a Yoke-Elm, or Hornbeam-Leaf; and the other of a folded Willow-Leaf. Here are also some others, in which you may discern a very exact Representation of the Fern. But the Figures most commonly exhibited on Stones, are those of Sea-Mosses; for as the Bottom of the Sea is always covered with these, it is natural to suppose, that after the universal Confusion and Mixture of Substances caused by the Deluge, these Mosses were left by the Sea on several Bodies, which afterwards petrified together with them. Monsieur de *Jessieu* found one in *France*, which represented the Foliage of the mournful Tree, so called, because it only blossoms in the Night. This Tree does not grow in *Europe*, and is only to be found in the *Indies*.

Chevalier. It formerly must have grown in these Parts, or else the Water of the Deluge must have transported it from the *Indies* hither.

Prior. There is one Mistake, which we are liable to in this Matter, and therefore must take care to guard against. When we find on any of these Stones an exact Resemblance of a Plant, a Leaf, or some Fruit that we are acquainted with, if these Leaves are bent and folded, if they cross each other, or lie one upon another, these are certain Indications that the Plant or Fruit so represented, is an Impression made by a natural Body. Near

The figured
Stones of *Flo-*
rence.

Florence, and in some other Places, are found Pieces of Stone or Marble, in which, when polished, some People fancy they see ruinous Castles, or entire Forests; but these Figures are drawn only by the Imagination, and are like those which they think they see in the

the Clouds, or like those imaginary Trees which the Hoar-Frost leaves on our Glasses and Windows. Put a little Oil between two polished Marble Plains, and rub them together, and the intermediate Air will disperse the Particles of the Oil, so as to form a Representation of a Forest, or little Tree; Their Origin. But you will not be able to discover the regular Likeness of any Fruit or Leaf: The Water in like manner produces fortuitously the same Effect on that Matter which it colours and petrifies.

In order to form one of these figured Stones of *Florence*, it will be sufficient, if several small Pieces of Chalk, round, square, triangular, or of any other Figure, incorporate with a Layer of Earth mixed with Clay or Loam. When the whole Mass comes to be petrified by a Water tinged with Vitriol, Cinnabar, or any other Matter, it is evident, that if the Body thus petrified be cut into Plates or *Laminae*, we shall find these Pieces of Chalk inverted or dispersed in irregular Figures, like the Ruins of a decayed Building; if after this the Lapidary so artfully cuts the Stone, that the imaginary Ruins may possess the lower Part of it, whilst the upper Part of the polished Plain is diversified with accidental Veins of different Colours, the Spectator will immediately pronounce it to be a Representation of Skies and Clouds: And if there happened to be any Fibres of Sea-Moss in the petrified Chalk, his Imagination will easily improve them into little Plants growing out of the Ruins.

We have now contracted an Acquaintance with some of those Productions of Nature, which she has lodged in the Bowels of the Earth to be employed for our Use when we want them: We have also ventured at some Conjectures on the Manner how the Sands, Salts, Loam, and Clay, by the Mediation and Agency of the Water, concur to form those Masses of Stone pursuant to the End for which God appointed them. In our way back to the Castle we may entertain ourselves with discoursing on the Usefulness of Jewels and common Stones.

As to the former, I shall leave them as we found them, without determining any thing concerning those Virtues, which some suppose inherent in them, leaving it to Time, and farther Experience, to discover to us whether

ther they have any such Properties peculiar to them; whether, when pulverized and mixed up in Medicines, they serve in any other Capacity than as Absorbents; or whether they are devoid of all medicinal Virtues, (as by any Discoveries hitherto, appears to me most probable); and only to be valued for their Hardness and Lustre. However this be, the Reputation which these Stones have always been possessed of for their wonderful Virtues, has gained them the honourable Distinction of being worn on the Finger, and of being looked upon in some Cases, as sovereign Preservatives. But however People may have been deceived, in reposing such a vain Confidence in their imaginary Virtues, they have found out the Art of making them really useful in another respect, *viz.* by engraving Figures upon them, and there-

Seals.

by converting them into little portable
Seals: An Invention this of great Use and Benefit to Society, seeing it serves by way of Credentials to prevent our absent Friends being imposed upon by Counterfeits, and to satisfy them that they receive what comes to their Hands in the same Form and Condition in which it was sent.

Farther, Jewels being the more bright and luminous Productions of the Earth, they naturally make a conspicuous Figure in the richest Dresses; they adorn the Majesty of crown'd Heads, and even set off the Charms of Virtue itself, seeing this, when set in Comparison with them, never fails to gain the Preference, and to eclipse the brightest Diamonds with its superior Lustre.

As to those Stones of a most enormous
The Use of common Stones. Size, which are found in the Quarries under Ground; is it not almost incredible, that such rough, unweildy, shapeless Masses of Matter should be capable of being cut, work'd, and ranged together in such a manner, as to form those durable and beautiful Edifices, which are not only so convenient, but also so conducive both to our Health and Security?

When the Descendants of *Noah* were obliged to disperse and seek for Settlements in different Parts of the World, finding all Places covered with Woods, and inhabited by wild Beasts, they built themselves Huts and
Tents

Tents with the Boughs of Trees, and the Skins of Animals ; but as these were a very insufficient Shelter against the Inclemencies of the Weather, and a still weaker Defence against the Violence of wild Beasts, or the more savage Treatment of ambitious Men ; how happy was it for them, living as yet in a State of War, and liable to continual Invasions, to find under their Feet, at a little Depth in the Earth, Masses of Matter soft enough to cut and fashion as they pleased, and yet sufficiently hard, when compacted and laid together, to defend them against the Attacks of their Enemies, or the Fury of the Elements ; and lastly, in so great Plenty as to furnish Matter for the Security and Defence of whole Kingdoms !

Thus by little and little, Villages and Cities grew out of the Earth, and Men found out the Art of placing and cementing Stones in the firmest manner, of erecting with them convenient Houses, strong Fortifications, magnificent Palaces for Kings and Rulers, and those august Temples in which all the Families of the Earth assemble at certain times, to pay due Worship and Adoration to their common Father, and to bind themselves under the most solemn Engagements, to observe inviolably all those Duties on which the Well-being of Society does necessarily depend.

The Sight of this Road we are just entering upon, which crosses that hard Paved Roads. paved Way, puts me in mind of another inestimable Advantage we receive from some of those solid Materials shut up in the Bosom of the Earth, I mean that of paving our Ways, and thereby procuring to ourselves, at all times, the Convenience of firm, passable Roads : Herein consists one of the principal Beauties of large Towns ; and this it was that formerly made the whole *Roman* Empire seem, as it were, but one large City, consisting of so many long paved Streets, that formed a Communication from one End of it to the other. *Rome* * was the Centre of a great Number of magnificent Highways, which ran through all *Italy*. Several of them crossed the *Alps*, the Country of the *Gauls*, the *Pyrenees*,

* See the History of the Highways of the *Roman* Empire by *Nicolas Bergier*, Counsellor at the Court of *Rheims* ; a very curious and learned Work, and too little read,

and the whole Kingdom of *Spain*. One of them reached from *Rome* to *Lyons*, from *Lyons* to *Rheims*, and from *Rheims* to the Channel; it was carried on again in *Great Britain*, and continued as far as *Scotland*. That which extended as far as *Byzantium* * was continued on the other Side of the *Hellepont* from *Chalcedonia* through *Asia Minor*, *Syria* and *Palestine*; then winding through the *Isthmus* of *Sues*, which joins *Asia* and *Africa*, passed through *Egypt* as far as *Syene*, and thence into *Ethiopia*. There were others that ran along the Coasts of *Africa* from one End of it to the other; and hence † possibly the *Romans* borrowed the Model of their paved Ways.

Chevalier. These are indeed surprizing Instances of Magnificence and Expence.

Prior. Your Surprize will be still heightened, if you compare the Structure of the Way we are now walking on, with that of the *Roman* military Ways. This, though one of the handsomest and best-built of the modern Ways, and though it is not above ten or twelve Years since it was first laid, yet begins to give way already, whilst that which it crosses has kept firm and intire for above fifteen hundred Years. The Reason is obvious: This Way which has been so lately paved, was raised upon a Foundation of Earth, not equally dense and solid in every Part; and consequently, as the Foundation shrinks, the Superstructure must fall in: Now, when Part of the Pavement has given way, that which was contiguous to it, wanting its Support, is easily separated from the rest, and made to fall in likewise by the repeated Shocks of the heavy Carriages that go over it: The whole Structure being thus disjointed, and the Coherence of the Parts destroyed, the Wheel-Ruts presently grow deep and uneven, the Waggoner strikes out into a new Tract along the adjacent Land; and thus a Work of great Labour and Cost becomes entirely useless, and must be repaired at a fresh Expence.

If the *Roman* Highways, through any Neglect to mend them in time, are decayed and broken down in some Places, yet there are several Countries where they still remain whole and entire. The *Appian Way*, which was

* *Constantinople*.

† From *Carthage*.

first carried from *Rome* to *Capua*, and afterwards continued from *Capua* to *Brundisium*, is still in good Condition, though it has been a High-Road above nineteen hundred Years; and we have some Ways in several Parts of *France*, which have subsisted upwards of fifteen or sixteen hundred Years. Now it is to their particular Structure that we are to ascribe their long Duration.

They first of all laid open with a Plow two parallel Furrows; then the Soldiers (for they were generally employed in Works of this kind in times of Peace) carried away the light loose Earth * that they found betwixt the Furrows, and dug till they came to a hard firm Bottom: They then filled up the Fosse or Bed which they had hollowed, with a more dense and weighty Matter; as for Instance, with a sort of hard Sand or Gravel taken out of the Rivers, or dug out of the Quarries; this done, they rammed the whole hard down, and smoothed it with heavy Rollers; nor did they always end their Work here, but oftentimes (to facilitate the Draining off of the Water, and to prevent any Mud or Dirt from soaking in, which would infallibly undermine and loosen the whole) raised a Terras or Causey several Feet above the Level of the Plain, consisting of four Layers or Stories of strong Masonry.

The Site or
Foundation.
Gremium.

The Causey.
Agger or Dorsum.

Chevalier. A Highway reaching from *Rome* hither built with four Layers of Mason's Work! Is it possible?

Prior. I will presently conduct you to a Place in the *Roman Highway*, where I myself opened the Earth, and will undertake to let you see the four Layers which you seem to call in Question. As we are walking thither, I will explain to you the Matter of them, and the Order in which they lay.

- * Hic primus Labor inchoare Sulcos,
Ac rescindere Limites, & alto
Egestu penitus cavare Terras,
Mox haustas aliter replere Fossas,
Et summo Gremium parare Dorso,
Ne nutent Sola, ne maligna Sedes,
Et pressis dubium Cubile Saxis, &c.

Statius, Lib. 4. Sylvarum, via Domitian.

On

On the Foundation of Earth, which, as I said before, was firmly compacted and levelled, they spread a Covering of Cement made of Lime and Sand or Haslock, about an Inch thick. The first Layer, which they placed upon the Cement, was of large flat Stones laid one upon another ten Inches high, and cemented together with well-tempered Mortar. The largest Stones of all were ranged along the Sides of the Causey.

The first Layer.
Statumen.

The second Layer consisted of Stones of a cubical, round, or oval Figure, and of many rough irregular Stones, sometimes mixed with Potshards and Pieces of broken Tiles and Bricks: All these were spread with a Shovel over the first Coat of Stones, and rammed down into the Mortar which cemented them together. This second Layer was about eight Inches thick.

The second Layer.
Rudus.

The third Layer consisted of a Foot of Mortar, not made of beaten Tile, for that would have been too expensive, but of Chalk, Sand *, or Haslock, mixed with Lime, as any of these Materials were near at hand. This Layer, which was sometimes called the Pudding or Pap, though more commonly the *Nucleus* or Kernel, filled up all the Cavities or Interstices in the inferior Layers, and settled into a hard level Coat: The great Difficulty we find in breaking it now, sufficiently proves how firm a Support this was to the upper Covering, especially when we consider the extreme Hardness of the inferior Strata, with which it is so firmly incorporated, as to form one compact, impenetrable Body, capable of sustaining the greatest Weight imaginable.

The third Layer.
Nucleus.

The fourth Layer.
Summa Crusta.

The fourth and last Layer, which they called the Crust, sometimes consisted of great hard Stones cemented together, as we find in the *Appian Way* †; sometimes of Gravel, or small Flints mixed with

* — Saxa ligant, Opusque texunt
Costo Pulvere, sordidoque Topho.

Stat. ibid.

† *Lips. de magnitud. Rom. Lib. 3. C. 10.*

Gravel, as we find in most of the military Ways *. The hardest Stones of all, the Free-Stone, and the larger Sort of Flints, they reserved for their Towns.

We are now arrived, my dear Chevalier, at that Part of the Highway where I made my Experiment: We may here measure the Thickness of the Layers.

Chevalier. I find here indeed all the Layers that you have been describing to me; but what puzzles me most is, to know how they came by this prodigious Quantity of little grey Flints with which the Road is every where covered, and that the more, as there are none to be seen any where else in the Neighbourhood.

Prior. These small Stones, Flints, and Gravel, were often brought hither from other Parts, the Country People being ordered to gather them in their Vineyards, their Heaths and plowed Lands, on the Banks of Rivers and the Sea-Shores, and to bring and lay them in Heaps by the Highway Side, where the Soldiers had Occasion to use them in their Work. Of these Materials they made a Covering six Inches thick upon the third Layer, and secured it on the Sides with two Borders of Earth, which they sometimes strengthened and consolidated with heavy Stones †, which they laid sloping for the Water to run off the Causey on to the Plain beneath, to prevent its soaking into, and thereby loosening the Gravel. By means of this Precaution the Traveller in all Seasons enjoys the Benefit of a dry, hard Road. It sometimes happens that the Flint Pavement is loosened by the falling down of the Banks or Borders which should support it at the Sides; but as the internal Layers do not suffer by it, the Damage is easily repaired. A Queen of France, in former times, having caused some of these Highways to be repaired and paved anew, had the Reputation of being the first Foundress of them, and in several Provinces they go by her Name to this Day.

The Borders.
Margines.

The Causeys of
Brusebank.

* *Misson's Travels into Italy.*

† ——— Umbonibus hinc & hinc coactis
Et crebris Iter alligare Gompis.

Stat. ibid.

Chevalier. Since the Layers, of which the Road is composed, are here uncovered at the Sides, and exposed to open View, pray let us take the Thickness of them before we go.

Prior. According to my Calculation, which is founded on repeated Experiments, (having measured them with a Foot-Rule) you will find the Depth of them all taken together to be about seven or eight and thirty Inches. Indeed the Difference in the Materials they were obliged to use, and in the Nature of the Soil, which was to be the Foundation of their Work, made a little Variation both in the Thickness and in the Order of the Layers (according to the Discretion of the Architect) sometimes necessary; but according to general Observation made in different Places, you will find me pretty near the Mark.

Chevalier. When we consider the great Advantage in having such convenient and magnificent Highways, and the great Trouble and Hindrance that Travellers meet with in passing through deep and rugged Roads, I am surprized that we do not imitate this Practice of the *Romans*, seeing then we might travel as far in two Hours, as we can now, in some Places, in a whole Day *.

Prior. This would be too great an Enterprize for us to undertake; but there is one thing which I am more surprized at, *viz.* That some pious, well-disposed Persons never thought of establishing a Fund by Legacies, to be applied in making Aquæducts for the Conveyance of wholesome Water to some Town which is destitute of so great a Blessing; or in repairing the publick Ways in those Places where they are in bad Condition; for sure nothing can better answer the End and Design of Religion, than to promote the common Good of Mankind as far as lies in our Power.

Chevalier. I assure you, if ever a Society comes to be set on foot, for repairing the publick Roads, I shall make it a Part of my Religion to promote so useful an Establishment.

* ——— Quæ solidum Diem terebat,
Horarum Via facta vix duarum.

Stat. ibid.

Prior. We have hitherto considered the Usefulness of Stones in building us Houses and Places of Security, and in making our Roads firm and passable at all times, and so commodious for the speedy Conveyance of our Merchandise from one Country to another. But they are still farther serviceable to us in supplying us with a Matter every way so fit and proper whereof to make durable Monuments to do Honour to the Memory of great Men, and to transmit remarkable Transactions and Occurrences down to future Ages.

The Use and Design of Sculpture.

Monuments, Columns, Basso-Relievo's, Coins, and Medals.

Stones and Medals are the true historical Registers of the World, as they deliver down to us the Names, the Features, and the memorable Actions of Princes that reigned near two thousand Years ago. The molten Brass, or obdurate Marble, receives from the Hand of the Statuary the Form of *Alexander* or *Socrates*, of *Cæsar* or *Virgil*, of *Erasmus* or *Charles* the Fifth, of *Louis le Grand*, or *Des Cartes*. To the Benefit of this Art we owe the Pleasure of beholding and conversing, as it were, Face to Face, with those who were the Ornaments and Blessings of past Ages, and of having before our Eyes the most illustrious Examples of Antiquity, to lead us on in the Paths of Glory and Honour, and to incite us to the Performance of virtuous and heroic Actions. This was the original Design of this noble Invention, and what procured it so universal a Reception in the World: But, alas! (if we except the adorning and beautifying our Churches, pursuant to another great End of this Art) how shamefully is it every where perverted and abused!

The Abuse of Sculpture.

I take a Walk, for Example, in a publick Garden, which has been adorned at a vast Expence with a great Number of Statues. It is natural to suppose that such a Profusion of the finest Marble, carved by the most ingenious Artists, was designed to convey some useful Lessons of Instruction; whereupon my Curiosity leads me to the first Figure that presents itself, which upon some Recollection I find to be the Representation of *Cephalus* and

and his Dog *Lælaps*, Objects that have very little in them to gain my Attention; nor can I see of what greater Importance it is to me, to behold how gracefully *Procris* takes an Arrow out of her Quiver between her Finger and Thumb, to make a Present of it to *Cephalus*: A little farther you have the Image of *Ceres*, or the God *Pan*, or some such sort of Folks, which the Generality of People have as little Knowledge of: In another Place you are presented with the Rape of *Orithya* by *Boreas*, or some such Adventure, contrary to those Rules of Modesty and Decency which ought to be observed, not only in private Families, but also in publick.

Chevalier. I have sometimes heard this made the Subject of a Debate, when it has been alledged in Defence of Sculptors and Painters, that those who employed them in adorning their Gardens and Houses with these fabulous Pieces, were generally Men of Taste; and moreover, that the greatest Part of these Statues were taken from ancient Originals, which are the best Models that the Moderns have to copy after.

Prior. In Answer to the second Observation, which is the only material one, I shall offer the following Remark: I am far from thinking that we ought to discard intirely all profane History, or to look upon those Masterpieces of Antiquity, which are still remaining, as unworthy our Imitation. The fine Statues and Paintings at *Versailles*, and the other Royal Palaces, were certainly designed by our Kings to be so many publick Schools of Education, for the Encouragement of Arts, and to refine the Taste of the Age; nor can we too much admire these excellent Models; but, on the other hand, it argues strange Bigotry and Narrowness of Mind to be pleased with nothing but what is ancient, and to multiply Copies of them without End. Let us imitate the Ancients, as Messieurs *Racine* and *Boileau* have *Euripides* and *Horace*: They indeed studied the *Greek* and *Roman* Poets to form their Taste, but did not therefore judge it necessary to write in *Greek* or *Latin*, or to be slavish Imitators of them in every particular; they thought for themselves, and struck out something new of their own. So ought it to be with Statuaries and Painters, and not be thus eternally

harping

carping on *Apollo* and *Diana*, *Hercules* and *Faunus*, and such ulelefs Representations.

Had the *Greeks* been nothing more than servile Imitators of the *Egyptians*, we should have had nothing transmitted down to us but *Egyptian* Monuments; whereas, by improving upon them, they made their Art an useful publick Register to the People of *Greece*, of all the memorable Transactions of their Country: All their Portico's, their Walks, and publick Places, were crowded with the Statues of renowned Warriors, Civil-Magistrates, wise Law-givers, Philosophers, Architects, Painters, Orators, and other famous Men. As they walked along, they could point to *Draco*, *Solon*, or *Aristotle*; here was the Founder of such a Sect, there such a brave Commander: At almost every Step in the Streets or publick Squares of *Athens*, they might learn an useful Lesson in Morality or History. Thus every one became acquainted with the remarkable Persons and Things of former Ages; and the Honours which were thus paid to the Memory of those who had distinguished themselves in their several Ranks and Stations, were so many Motives of Encouragement to others, to exert themselves in their respective Occupations and Professions to the utmost of their Abilities.

Nothing is more generally talked of amongst us than Taste, though I must needs think, that we should give a much better Proof of it, if instead of all this Trumpery of Mythology and Metamorphoses, our publick Places and Gardens, our Galleries and Tapestry, were made to yield a more rational Entertainment, and exhibited to us such Figures and Representations as might serve to improve our Understandings, or perpetuate the Memory of great and useful Examples; for Example, if we could say, there is *Charles* the Wise and his Constable *Bertrand de Gueclin*; there is *Lewis XII.* surnamed the Father of his People, and his excellent Minister Cardinal *D'Amboise*. What a Fund of Pleasure and Instruction might we reap at the same time, from a spacious Portico, where in one View we might take a Survey of all our most famous Generals; in another be presented with the Figures of those who have been most conspicuous in the learned World; in a third, with the most ingenious Mechanicks, and such as have signalized themselves by their Improvements of Arts

or

or Commerce ; and, in a word, all those who have zealously promoted the Good of their Country by their Courage or Learning, by useful Discoveries, or indefatigable Industry ! Nor ought we to exclude those who render themselves illustrious in other Parts of the World, seeing Virtue and Knowledge are amiable and praise-worthy where-ever we find them. If *Erasmus*, *Coster*, and *Faustus*, have deserved well of Society in general, their Memories ought to be as dear to us as to their own Countrymen, and have as good a Right to be honoured with Statues at *Paris*, as at *Rotterdam*, *Harlem*, and *Mentz* ; nor is there any, I believe, who would not be well pleased to see in a publick Walk, instead of a *Marsyas* or an *Ixion*, the Statue of *Huygens* next to that of Mr. *Paschal*, *Newton* at the Side of *Malbranche*, *Lewis Elzevir* along with *Robert Stewens*, and my Lord *Arundel* by Monsieur *Colbert*.

By these means, we might soon contract a familiar Acquaintance with History in general, make our Walks instructing as well as diverting, and become great Scholars without having ever learned to read. But we seem to have so little Regard to Truth in Painting and Sculpture, that nothing is fashionable but what is fabulous ; or if our Taste is formed for the Study of History, we cannot relish it, unless it be dashed with Fiction : Insomuch that we are come to that pass, as not to know the true Character or Fashions of our own Nation a Century ago, by the Descriptions that are given of it. Our Kings and great Commanders are ashamed to be seen in *French* Dresses at Court, or at the Head of their Troops ; but they must be painted forsooth, dressed up to the Mode of ancient *Greece*, or else all is spoiled. Does a private House-keeper, or a Scholar, sit for his Picture ? the Painter, instead of drawing them in their proper Habits, (which might serve by way of Characteristick to distinguish the Person so dressed, and the Age in which he lived) has his Head so full of Antiquity, that every thing must be according to the ancient Taste. A Gentleman must be armed with a Cuirass, like the God of War, and his Head adorned with a spruce well-buckled Perriwig. How admirably well do these suit each other ! He dresses a Citizen in a military Vestment, with his Arm bare like a

Roman

Roman General ; and a *Philosopher* in his Study must be disguised in a Cap and Gown of so odd a Make, that you are at a Loss to know whether he meant him for a *Muscovite*, or an Inhabitant of *Tonquin*.

M I N E S.

D I A L O G U E XXVI.

The PRIOR and CHEVALIER.

Prior. W E L L, Sir, are you pleased with your Journey to the Forges, and the Person I appointed to attend you ?

Observations
collected from
several Forges.

Chevalier. I cannot sufficiently express my Thankfulness for his Civilities, and your obliging Care. It was a quite new Scene to me ; methought I saw *Vulcan's Shop*, all *Ætna* laid open to my View : and I can scarcely help fancying that I hear the Hammers of the *Cyclops* still founding in my Ears.

Prior. I do not doubt but you saw the whole Process from Beginning to End.

Chevalier. First I saw them take the Iron Ore out of two Places dug a little way in the Earth, in one of which the Ore was incorporated with a stony Substance,

Iron Ore,

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which

which they broke in the Stamping-Mill in order for washing and melting. In the other it was mixed with a sort of Earth or coarse Sand, which they cast into a flat

The Washing-Trough.

Tub ten Foot square, and two Foot deep, through which they keep a constant Stream of Water running, all the time stirring and pounding the Ore in the Tub, so that the Water may wash away the earthy Particles, whilst the Metal, which is specifically heavier, subsides to the Bottom. They told me, that a Furnace which yielded from two thousand five hundred to three thousand five hundred Weight of cast Iron in 24 Hours, would require in that time about fifty Puncheons * of Coals, and near fifteen Ton of washed Ore. As private Interest must always give place to the Good of the Publick, it seems the King appoints proper Officers to dig the Ore where-ever they find it, paying a small Acknowledgment of about twenty *Deniers* †, as I remember, *per* Ton, by way of Satisfaction to the Proprietors of the Land. Immediately after each Casting, which is once every Hour and three Quarters, two lusty strong Fellows are appointed to feed the Furnace with fresh Supplies of Coal and Ore. They add moreover a large Quantity of Flux-stone, which is a sort of hard, stony Earth, and necessary to promote Fusion. Pray, Sir, can you explain to me the Reason of this ?

Prior. The Flux-stone is preferred by the Workmen for this Use, for as much as it abounds with Particles of Iron, and therefore increases the Quantity of metallick Matter : it does also, as you say, facilitate the Business of Fusion. The Ore consists of metallick, sandy, and earthy Particles ; now the Business is to separate these three distinct Kinds of Matter, or else to extract the Metal from the Sand and the Earth : The first of these Offices is performed by Lotion in the Trough or Washing-tub, the Water carrying off a pretty large Quantity of these extraneous Matters. The melted Metal is nothing but a Torrent of liquid Fire, which rarefies and keeps in Motion the metallick Particles, which upon the Extinction

* A Punccheon is a Measure containing about a Hogshead.

† Twelve *Deniers* make one *French* Sous or Penny.

of the Fire coalesce and subside one upon another. The vitrified Sand is also a liquid Mass of Fire keeping in a State of Agitation the finer Grains of Sand, and the saline Particles, which after Ignition fix into a consistent Body. The calcined Earth is a Subject consisting of Parts easily separable, which being penetrated by the Fire are reduced to Ashes. The Sand being put into a State of Fusion by the Fire, the metallick Matter, which is more weighty by Nature, disengages itself from it, and subsides to the Bottom; for these two Bodies, being of different specifick Gravities, are easily separated by the Action of the Fire; whereas the Earth, which is composed of light flaky Masses, is easily entangled in the fused Metal, the vitrified Sands, and the alkaline or spongy Salts that are mixed with them. The greater the Quantity there happens to be of this Earth or calcined Powder in the Metal, the coarser, more brittle, and imperfect it proves; the less of this heterogeneous Matter there is in the Iron, the more malleable, ductile and solid it is, and approaches nearer to the Nature of Steel, which is only pure unmixed Iron. Now in order to purge and putrify the Metal as much as possible from this Powder which infects it, they must at the time of its Fusion inject into it some Matter, which may lay hold of as many Particles of the calcined Earth as possible, without imbibing the Metal; and this is performed by Vitrification. The Sands and Salts of the Flux-stone, being separated by the Fire, give free Liberty to the Particles of Iron to disengage themselves, and at the same time absorb a great Part of the Earth that was mixed with the Ore. For want of Flux-stone, Flints or River-sand may be made use of, which when vitrified purge the Iron from the Dross, in Proportion to the Quantity of Scoriae or calcined Earth which they lay hold of. Some Masters of Forges use Lime instead of Flux-stone or Sand; but as this is nothing but a calcined Earth itself, it cannot have any absorbing Power, and serves to foul instead of purifying the Ore. The only respect in which Lime can be serviceable, and supply the Place of Flux-stone or Sand, is by serving as a Crust or Covering to reverberate the Heat, and to make it act with more Force inwardly on the Ore which is mixed with the Coals.

Chevalier. This is like a Practice which I have seen put in Use by Farriers, Smiths, and other Workers in Metal, who cover their Fires with the metallick Scoria or Slag of their Forges, so that you would think they meant to choak them quite up: They every now and then water the Slag with a sprinkling Brush, to make it cake round the Fire. By means of this Precaution the Flame is suppressed, and the Heat, by being reflected inwards, acts more intensely on the Iron that is to be worked.

Prior. I am very glad to find you have improved so much by the Workmen, who are oftentimes the best Instructors in Things of this Nature; but, pray, let me hear what becomes of the Ore, thus shut up and mixed with the Coals.

Chevalier. It is no sooner melted than it runs along the Bottom of the Furnace, which is made sloping, to a sort of Flood-Gates, which are drawn up for it to pour down in a Torrent of liquid Fire, into long Trenches made in the Sand, or into Moulds of different Figures, to be cast for Cannons, Chimney-Backs, Bomb-Shells, Grenado's, Mortar-Pieces, Pipes for the Conveyance of Water, Caldrons, &c. I was highly pleased with seeing them cast all these.

Prior. What do they do with the Iron which they run into the Trenches?

Chevalier. After having diffused itself equally from one End of the Trench to the other, it consolidates into a

The Pig of Iron.

triangular Mass, which they call a Pig of Iron, weighing from twelve to eighteen hundred Pounds; this they run on wooden

Rollers to the Mouth of the fining Furnace, where they gradually melt it (not to a Degree of Liquefaction, but) till it resolves into a soft Paste, which

The fining Furnace.

the Workmen keep stirring with their Iron Prongs; then they take from it a Piece of about sixty Pounds Weight

which they beat with light Hammers, till it comes to a Consistency; this done, they give it a heating in the fining Furnace, and thence carry it on an Iron Sledge, and subject it to the Discipline of a monstrous Hammer.

Hammer.

Hammer, weighing upwards of six hundred Pounds, the Noise of which may be heard above three Miles off. It is made to rise and fall by the Motion of a Wheel turned by a running Water. They turn the Iron under this Hammer, till it is beat out into an oblong Square.

The great Hammer.

Prior. They tell you that the Force of Percussion inflicted by this Hammer on the Iron, is so great, that it penetrates the very Heart of the Mass, agitates the finest Particles of the Iron, dissipates the calcined Earth with the Scorix; and other heterogeneous Matter, and makes the whole perfectly malleable, by consolidating the metallic Particles, and uniting them in close Contact.

Chevalier. After the Mass of Iron has passed the Operation of the great Hammer, it is carried back again to the fining Furnace, to be thoroughly purged of its Dross and Scorix; where, while it is perfecting, it facilitates another Operation; for it thereby contracts so intense a Heat, as is sufficient to resolve the Pig-Iron that is near it. Last of all, it is carried to the Forge or reheating Furnace to soften it, and fit it for the Anvil, on which they hammer it into flat triangular Pieces for Plowshares, into square Bars for all sorts of Smiths Work, or into Plates of different Dimensions.

The Forge, or reheating Furnace.

Prior. I find nothing has escaped your Observation.

Chevalier. I also took a Memorandum of the Expences they were at every Day for Coals, Ore, Flux-stone, Labourers Wages, &c. and upon casting up the whole, I found, that a Furnace which yields one Day with another, three thousand Weight of cast Iron, stands the Master of the Forge in a hundred and twenty Livres * every 24 Hours; and consequently the prime Cost of a thousand Weight of unwrought Iron amounts to forty Livres.

The prime Cost of a thousand Weight of unwrought Iron.

But as this Iron still contains a great deal of Dross and Scales, which cannot any other way be separated from it, than by undergoing the Discipline of the Furnaces and Hammers several times, it will lose

The prime Cost of a thousand Weight of wrought Iron.

* A French Livre is about one Shilling English.

in the Course of these Operations, one third of its Weight ; so that fifteen hundred Weight of cast Iron will hereby be reduced to a thousand Weight of wrought Iron ; which Waste raises the Cost of a thousand Weight to sixty Livres : If we take still farther into the Account, the Wages of the Workmen, and the Expence of Coals, for keeping up the Fires of the refining and nealing Furnaces, these Articles will amount to 45 or 46 Livres more ; so that upon the whole, a thousand Weight of wrought Iron will stand the Master-Founder in 106 Livres, the least Penny, before it is fit for the Use of the Locksmith.

Prior. Have you any Thoughts of building a Forge in your Woods, that you have been at so much Pains to inform yourself of the Charges of making Iron ?

Chevalier. The Scheme is feasible enough ; and they assure me that it would turn to very good Account, provided Wood might be had under four Livres per Cord *.

Prior. Establishments of this kind are not now allowed of, but upon very deliberate Consultation, because the Consumption of Wood used by a single Forge is so great, that it oftentimes proves a Detriment to the neighbouring Country ; however, the Knowledge of these Particulars is not without its Use in many other Respects ; for as Iron is a Commodity for which there is so general a Demand, it must be allowed to be a part of Prudence, to inform ourselves of the real Value of it. Besides, what we learn from one Forge may introduce an Acquaintance with the Methods used in working other Metals.

Chevalier. But before we examine into the Condition of Gold and Silver, as they are found in the Mines, pray, Sir, do me the Favour of your Opinion on the Manner of making Steel and Tin ; for they seem to me to make a great Secret of it.

Prior. The Art of converting Iron into Steel is much practised by the *Germans*, who have proper Furnaces erected purposely for this Work. In these they put large Masses

Steel.

* A Measure eight Foot long, and four Foot high, when the Wood is cut three Foot and a half long. But this Measure varies in different Places.

of Iron, (which have passed through the fining and Reeling Furnaces) where it is strongly ignited by a vehement Fire, till two-thirds of it be wasted away; they then Forge it, and the remaining third is pure Steel. There are also Forges where they cover the Iron over with a Paste made of Ashes which have been purged from their Salts, and with the Scrapings of Horn; and this they call Case-hardening.

Case-hardening
Iron.

Nor is the Art of making Tin a greater Secret, than that of making Steel; for Tin is nothing else but Iron Plates tinned over. Now in order to become Tin, the Iron-Plate must undergo three very simple Operations: First, they whiten it in Tubs filled with Water and Vinegar; then, after having rubbed it over with a Sponge dipt in Glue, they powder it with *Sal Armoniac*, or Salt of Tartar, perfectly pulverized; and last of all, they immerge it half a Minute in an Iron Crucible, eighteen Inches deep, filled with melted Tin: Then it is what we call a Tin-Plate. I need not tell you what use they make of this Metal. Let us now proceed to the other Metals.

I have now and then made it my Business to consult some Travellers * on the Subject of Metals; from whom I have the following Information: Gold is found either in Mines under Ground, or in the Sands of certain Rivers, though probably they are both originally the same; it being very natural to suppose that those little Spangles of Gold which are found in the Sands of Rivers, were washed away from the Mines by some Current of Water passing through them. These little Particles of Gold-Dust are separated from the Sand or Mud of the Rivers, first by Washings, and then by Mercury. Mercury, or Quick-silver, is a dry, white, mineral Water exceeding ponderous, and is found in Cavities under Ground, either in a State of Fluidity or Amalgamation: the latter is, when it is united to Sulphur and Earth, in the Form of a hard Mineral, called Vermilion or Cinnabar. Now as they can make artificial Cinnabar, by mixing and combining

* See *Becher, Stahl*, and especially *George Agricola*, whose Book of *Minerals and Metallurgy*, though written above two hundred Years ago, is superior to any Work of the same kind published since, both in Beauty of Style, as well as in Accuracy and Extent of Learning.

Mercury with Sulphur, so also can they resolve native Cinnabar into its component Parts by Fire, and extract from it a pure fluid Mercury, which has that peculiar Property of adhering to Gold and Silver. In order to make a perfect Secretion of the Gold-Dust from the other heterogeneous Matter, they pour Mercury upon it, which immediately lays hold of all the golden Particles, without absorbing those of the Earth : Now the Mercury, notwithstanding its great specifick Gravity, consists of Parts so fine and subtle, as to be easily rarefied and sent off by the Fire ; they therefore separate the Mercury from the Gold, either by Evaporation, or by straining it through the Pores of a Leathern Bag * ; in either of which Cases the Gold is left behind alone, in the Bottom of the Crucible, or of the Bag.

The Gold of the Mines is either in Grains or in Stones ; the former is, sometimes found in hard Masses, weighing one or two Drams ; and now and then in Lumps, weighing two or three Marks. These Grains are separated from the Earth they are mixed with by plain Washings ; this Method of purging Gold from impure Mixtures without the Help of Fire, being the most advantageous, and at the same time most uncommon, it being peculiar to the rich Ore that is dug in the Mountains of *Chili*.

The Gold which is found in Stone, as is most generally the Case, is a hard Mineral, abounding more or less with little brilliant Particles of this Metal, which are interspersed and mixed with those Veins of Earth that run through the Ore, and which constitute the Richness of it. These Spangles or Specks of Gold are oftentimes found incorporated with Rock, Marble, or precious Stones, according as the Water has chanced to introduce them into the Pores of these Bodies.

In order to separate the Gold from the other superfluous Matter, they first bruise the Mineral with Iron Pestles ; they then carry it to the Stamping-Mills, where it is reduced to Powder, which they sift through a fine Copper Sieve ; this done, they mix it up with Mercury and Water into a Paste, which they knead and work in wooden Troughs filled with Water. This Operation is con-

* See pag. 52.

tinued two Days in a hot Sun, during which time the Mercury imbibes all the Particles of the Gold, without cohering with the coarse Earth or Sand, which is easily washed away by the Water, upon inclining the Trough, the Mass which remains concreted at the Bottom, consisting now of nothing but Gold, Mercury, and some fine Earth; the last of which they disengage from the Mass by repeated Affusions of hot Water, and the Mercury by Evaporation caused by Fire; the Gold remaining behind, though not yet perfectly pure, and free from all Mixture of foreign Matter, whether of an earthy or metalline Nature; they being obliged, in order to perfect the Secretion, to have recourse to strong, dissolving Menstruums, which they call refining it.

Now Gold may be refined several ways; first by Antimony; secondly, by a Sublimate; thirdly, by *Aqua fortis*; and fourthly, by Lead and Ashes.

Antimony is a sort of metalline Stone, of nearly the same Colour with Lead-Ore, and which, when fused, has the Property of laying hold of, and absorbing, all fine Earths and Metals that it meets in its way, except Gold, which remains almost untouched by it; and therefore, being the heavier Body, falls like a *Regulus* to the Bottom of the melting Cone. The fouler or fuller of Allay the Gold is, the greater Quantity of Antimony is required in the Fusion of it. The Gold being thus separated from the other heterogeneous Matter, subsides to the Bottom, and becomes almost perfectly fine, the Scum of the Antimony, and the other Bodies swimming at the Top, in the Form of *Scoriæ*, which the Mass of Gold purges itself from, and sends off in Exhalation upon its being again put into the Fire.

Refining by Antimony.

Sublimate is an artificial Composition of Mercury, and Spirits of Sea-Salt, which when fused with the Gold, volatilizes and sends off in Vapour all the other Metals that are mixed with it. The Refiners avoid, as much as possible, making use of these two Methods of refining, because both the Antimony and the Sublimate abound with Particles of Arsenick, the very Steam of which is rank Poison, and proves fatal, if not guarded against with

Refining by Sublimate.

all imaginable Precaution. They therefore most commonly employ *Aqua fortis* in this Operation.

Refining by
Aqua fortis.

Aqua fortis is a Liquor composed of Spirits, distilled from Nitre and Vitriol, though perhaps the Vitriol is of no other Use in this Composition, than to separate

the nitrous Acid from its Basis. Some moreover add Spirit of Arsenic. This Water has the Property of dissolving Silver, Copper, and other Metals; but leaves Gold in its natural State, without causing any Alteration in its Parts, there being no Preparation but *Aqua regia*,

Aqua regia.

with a Solution of *Sal Gem*, and *Sal Ammoniac*, that has Spirits fine enough to dissolve Gold; but this Water will not per-

form the same Office on Silver and other Metals, being so subtle, as to pervade their larger Pores, without destroying the Cohesion of their Parts: But in refining Gold, they most commonly use *Aqua fortis*, because this imbibes all the other metalline Matter, and leaves the Gold pure and intire by itself. In order to refine one Mark * of Gold, they mix with it several Marks of Silver in the same Crucible, which is a Vessel made of Clay and powdered Stone, in the Figure of an inverted Cone or Pyramid. These two Metals being thoroughly melted and mixed together, they pour them into common Water, wherein they separate into Grains, about the Bigness of Pease or Barley-Corns †.

The Metals thus granulated, they put them in a Stone Pot, and set it on the Fire, adding a Pound of *Aqua fortis* to every Mark of Metal: They then lute or cover the Top of the Pot carefully with Clay, and in less than an Hour, the *Aqua fortis*, which receives additional Strength from the Action of the Fire, dissolves the Silver, so as to make it seem like so much *Aqua fortis*, whilst the Particles of Gold disengage themselves from those of the Silver, and precipitate to the Bottom of the Pot, in the Form of a Calx; they then uncover the Pot, and pour off the liquid Matter from the Gold, which is rendered more pure than before it was mixed with the Silver.

* A Mark weighs eight Ounces.

† *Boissard's Treatise of Coins*.

In order to bring it to Perfection, they fuse the golden Calx again with Silver and *Aqua fortis*, and repeat the Operation till it is thoroughly purged from all Allay of other Metals, which at length become totally absorbed by the *Aqua fortis*. Last of all, they melt the Gold Calx by itself, and cast it into Ingots or Wedges, using nothing else but a little Borax for this Purpose, which presently collects and unites all the Particles into one solid Mass.

Chevalier. I cannot but admire the Virtue of this Water, which so faithfully collects all the Silver, without purloining any of the Gold: But must we then sacrifice two or three Marks of Silver, to obtain one of pure Gold, seeing so much of the former is intirely absorbed and lost in the *Aqua fortis*?

Prior. Far from it; we do not lose so much as one Grain thereby; but, on the contrary, have it all restored to us in its greatest Purity and Perfection. They take all the *Aqua fortis* in which the Silver is dissolved, and pour it into earthen Pans, adding seven or eight times as much Spring-Water. They then put into every Pan several Ingots of red Copper. What inherent Virtue in this Metal causes it to be attracted by the *Aqua fortis*, I cannot tell; but this Menstruum immediately discharges the Silver, and falls to work upon the Copper, which it dissolves in the Space of 24 Hours, letting the Silver precipitate in little Parcels to the Bottom, in the Form of Ashes or Powder; which being put into a Crucible, and set on the Fire, do, by a kind of Resurrection, reassume their original Form, and from a Heap of Dust are changed into a solid Mass of the purest Silver imaginable.

Chevalier. Could I be inclined to find any Fault with the Country, it should be for not having a Goldsmith in the Neighbourhood, that I might have an Opportunity of being an Eye-Witness of these surprizing Operations.

Prior. The Depart or Separation of Metals with *Aqua fortis*, is doubtless an Invention highly deserving our Curiosity, and the publick Thanks of all Mankind, and would entail immortal Honour on the Memory of its Author, and our Benefactor, were he known to us. He

lived probably about the Beginning of the XIVth Century.

Refining by the Cupel.

There is a fourth Method of refining Metals, by the Help of Lead, which is performed in the following manner: They melt a certain Quantity of Lead in a Cupel, with one seventh or eighth Part of the same Quantity of Gold or Silver. The Lead, when fused, insinuates itself into the Pores of the Crucible, and is dissipated in Fume and Scorixæ, carrying off with it the impure Mixtures and Allay, that infected the more perfect Metal, which subsides to the Bottom of the Crucible in the Form of a Button.

The Assay or Proof of Metals.

This last Method of Separation is farther made use of, in the Proof or Assay of Silver, which is in order to know to what Degree of Perfection it is refined by the *Aqua fortis* or otherwise. They first of all take the exact Weight of the Silver that is to be assayed; after the Lead is evaporated, they weigh again the Button of Silver that is left at the Bottom of the Cupel; they learn by the Diminution of its Weight, how much Allay it before contained; and from the Proportion hereof, judge what Degree of Purity the whole Mass is of. In the Assay of Gold, they make use of another Expedient: The Litharge, which is formed by the Lead, has the Property of extracting and carrying off the Copper, the Earth, and the Dross that is mixed with the Gold; but not the Silver, which being of inferior Value, greatly debases the Gold that is allayed with it. To know therefore exactly what Degree of Perfection the Gold has acquired in its Refining, they take a small Quantity of it, for Example, a Dram, and melt it with two Drams of pure Silver; then with a small Hammer and Anvil, they beat it into a thin Plate, and dissolve it in *Aqua fortis* over the Fire; in this Operation, the dissolving Menstruum imbibes the two Drams of Silver, and also that which was before in the Gold; what remains is pure and perfect Gold. The Diminution which this little Quantity has suffered in Weight, in undergoing the Proof, is the Rule of Proportion, whereby they know the Degree of Allay in the whole

whole Mafs, and how far it falls short of Perfection and full Standard.

Chevalier. I have often heard talk of the Standard of Gold, but am at a Loss to know what they mean by this Term.

Prior. The Standard of Gold and Silver is the Degree of its Purity and Fineness, and varies with it. Gold is said to be perfectly fine, when it is free from all Mixture of any other Matter. Silver is said to be so, when it is not allayed with any less perfect Metal; nay it must also be free from any Mixture of Gold; and indeed it would be the Height of Folly to let that pass for Silver, which is of a much greater intrinsick Value, and which would amply reward the Pains of extracting it. We may suppose a Mafs of Gold to be divided into 24 Parts, and each of these again into 4ths, 8ths, 16ths, and 32ds. Every 24th Part of a Mafs of Gold (of whatever Weight it is) is called a Carat; and when the Mafs, after being refined and proved, contains nothing but pure Gold, it is then said to be 24 Carats Standard, or perfectly fine, without any Allay. But let it be observed by the way, that the Refiners lay it down for certain, that Gold always comes something short of this Standard, being never without a 4th, a 16th, or a 32d Part Allay. If then Gold loses by Cupellation or Assay two 24ths, for Example, of its Weight, we find that it contained but 22 Parts of pure Gold, and two of Allay, and therefore call it Gold of 22 Carats Standard. Silver is also divided into twelve Parts, which they call penny Weights, and each penny Weight into 24 Grains. If, for Example, you take from a Wedge of Silver a Piece weighing half an Ounce, and melt it in a Cupel with a proper Quantity of Lead; if, after the Lead is passed off in Fume, there still remains half an Ounce of Silver, we then pronounce the Wedge of Silver to be twelve penny Weights Standard, or in its most perfect Purity: If, on the other hand, the half Ounce loses in the Operation one or two 12th Parts, we say, that the Wedge is eleven or ten penny Standard; which is as much as to say, that ten or eleven Parts in twelve of the Mafs is pure Silver, and the rest Allay. In speaking therefore of the Standard of Metals, we are not to understand by the Carat and penny Weight any fixed

fixed and determinate Weights, but only relative ones respecting the Mass of which they are Parts. Thus an Ounce of pure Gold is said to be 24 Carats Standard, as well as a Mark of the same Metal, because the former consists of 24 Parts of pure Gold, and the latter of no more, though the Carat of the Mark weighs eight times as much as the Carat of the Ounce.

It is the Prerogative of Sovereigns to fix the Standard of Gold and Silver, who have wisely appointed by Law, that all Goldsmiths and other Workers in these Metals shall deliver out no Gold under the Standard of 24 Carats, nor any Silver under that of 12 penny Weight. The Design of which Prohibition was to prevent their melting down the current Coin in the Business of their respective Trades; the Loss which they would sustain by converting Metals of an inferior Standard into Works of pure Gold and Silver, being the most effectual Way to discourage a Practice which might in the End prove destructive to Commerce by occasioning a Scarcity of Coin.

But as these Laws bore hard upon the Goldsmiths, in obliging them to sell nothing but what is perfectly pure, and no less upon the Masters of the Mint, who were thereby also obliged to deliver out so much Specie of such a Weight and Standard after the refining and working their Metals, seeing, as was before observed, it was almost impossible for them to do this without being considerable Losers, on account of the Diminution which the Metal suffers in Weight, in going through its several Operations, and the Loss of pure Metal in the Litharge and Scoriae that are left behind; it was therefore thought just and reasonable to mitigate the Severity of these Laws, and to look upon the Intent and Meaning of them sufficiently answered, provided the Weight and Standard came very near to those prescribed; but as some fixed Rule was necessary to go by in this Case, the Laws have accordingly circumscribed this Indulgence within certain Bounds. A Goldsmith, for Example, that sells Silver eleven Pennies eighteen Grains Standard, is judged to vend good statutable Silver, though it wants six Grains of full Standard, and consequently contains so many of Allay. And this

is called in *French*, *Remede*, or an Allowance to indemnify the Workers in Gold and Silver for necessary Losses. And this Allowance is twofold, that which is granted on the Standard, and that which

The Remedy or Allowance, on Standard.

is granted on the Weight; the former is called Standard-Allowance, the latter Weight-Allowance. Two Instances will illustrate the Matter to you: The Master of the Mint is obliged by Strictness of Law to deliver out *Louis-d'or's* at the Standard of twenty-two Carats; but they are accepted as good at twenty-one Carats and three Quarters: This is one Quarter of a Carat Standard-Allowance granted to him. He is also in like manner required to deliver out Silver Coin at the Standard of eleven Pennies; however he is reputed to have made it good Standard, provided it is not under ten Pennies and twenty-two Grains: This is two Grains of Allowance granted him on the Standard. On the other hand, if for a Mark of Gold Bullion belonging to the Government, he returns in coined Money, fourteen Grains short of that Weight, and for a Mark of Silver, forty-three Grains short, he is accounted to have returned full Weight, though there be as many Grains wanting as amount to the Value of five *Sous*: This is called Allowance on the Weight: But as there is an Allowance on Standard and Weight, so On Weight. is there also a *Foiblage* of both, which Word denotes a Diminution of the Weight or Standard below what the Law allows; and this Practice is punishable. When Gold or Silver is considerably beneath the Standard appointed by Law, it is called base Metal: When Gold is under seventeen Carats, if it be of a reddish Cast, we say it is Gold sophisticated with Copper; if white, sophisticated with Silver: When Gold is under twelve Carats, and Silver under six Pennies, that is to say, having more than one half Allay, it is called *Billon*, or counterfeit Coin; though the Word *Billon* does also signify Copper *Billon*, what. Money, mixed with a little Silver; as also all Money of good Weight and Standard, that is cried down, or called in to be new minted. Thus, my dear Chevalier, have I explained to you in a few Words the chief

chief of those things that relate to the Origin and Refining of Gold, and which no Gentleman ought to be ignorant of. We will now suppose it to have passed through the several Operations necessary to bring it to a State of Perfection, and consider the several Uses we apply it to.

It is not from Fancy or Prejudice that we prefer Gold to all other Metals; but this Preference is founded on its real intrinsic Value. It is of all Metals the most solid and weighty, and capable of being refined to the greatest Degree of Perfection. It is, beyond all Dispute, of the most beautiful Colour, and approaches nearest to the Brightness of Fire: It is the most ductile and malleable of Metals; nor does it besmear the Hands of those that work it, like others, but embellishes and gives a Lustre to every thing it touches. To these rare Qualities we may add another, that still more enhances its Value, and deservedly gives it the Preference to all other Metals; which is, that it does not consume by Rust, nor lose aught of its Weight by passing through the Fire.

It is not to be wondered at, that Mankind should agree with one Consent to fix upon a Substance of so perfect and permanent a Nature, to be the common Price and Purchase of every thing they wanted. Before this precious Matter was discovered in the Bowels of the Earth, Men negotiated their Commerce by bartering one Commodity for another. Thus Wine was given in Exchange for Oil, and Corn for Flax, every one trucking what was superfluous to him for what he wanted. But this way of Traffick was subject to great Inconveniencies: Two Nations or Neighbours might be over-stocked with the same Commodity; or if the Productions of their Lands were different, it was a difficult Matter to make an exact Estimate of their true Value; so that it was a very hard Matter to settle Equivalency in wholesale Bargains, and almost impossible in retale; and Men were under a Necessity of dispensing with many things, for want of such Commodities as were suitable to the Occasions of those that had them. Now Gold, by reason of its Purity, Ductility, and Incorruptibility, appeared to them the most proper Matter, whereof to make a com-

mon Standard of the Value of every thing, and to be given in Exchange for all sorts of Commodities; and as this beautiful Metal was very scarce, it was agreed upon amongst them, that a little Portion of it should pass as an Equivalent for a large Quantity of other Merchandize. They were sensible how commodious and advantageous a thing it would be to be able, by the Help of a little Metal, both so portable and easily concealed, to travel to any Part of the World, and defray all our Expences by the Way, without any Incumbrance, or the Trouble of bartering one Commodity for another. This way of bargaining was found so short and commodious, that it came by degrees into Practice every where. The only Inconvenience that attended it was, that every body was obliged to carry with them their Scales to Market, to inform themselves of the true Weight and Value of what they received; but a Remedy was soon thought of for this, by making little flat Pieces of Gold and Silver, impressed with a publick Stamp by Authority of State, to ascertain the true Value of it, and to satisfy the Seller, that what he received in Payment for his Goods was of such a certain Weight and Standard. Hence *Moneta*, [Money] from *Monere*, to inform or notify. But as Gold, on account of its Scarcity, was reserved for the Payment of large Sums, they had recourse to other Metals that were more plentiful, for current Expences, and the Business of Retail. Thus have I given you an Account of the Origin of Money, and the principal Use of Gold; we will now proceed to examine into the Uses to which it is applied.

This Metal is fashioned by a great Number of Trades into an almost infinite Variety of Ornaments for Dress, no less curious and valuable for the Skill of the Workman, than the Matter on which he exercises his Art. The Goldsmith hammers it into a thousand different sorts of Work, some for the Use and Wear of private Persons, others for the Decoration of Churches, or the splendid Equipage of Princes. The Jeweller uses it to set off and give a greater Lustre to his precious Stones. The Embroiderer artfully works it in Silks, Cloths, Lace, &c. he mixes and shades it with different Colours.

The different
Uses of Gold.

he

he draws a Flower, a Leaf, or any other Device, and paints Nature to the Life. The Gilder lays it on Metals, Leather, Wood, Stones; he employs it in beautifying the Wainscot of Rooms, the lofty Roofs of Palaces, and the Domes of Churches.

Chevalier. How comes this Gold, which is only thinly spread on the Surfaces of Bodies, and not incorporated with them, to last so many Years, though all the time exposed to the open Air and the Weather?

Prior. This arises from its natural Incorruptibility, and the Art of the Gilder in laying it on.

Chevalier. What Pity we have none of this Profession here in the Country, to have an Opportunity of seeing them practise this Art!

Prior. I find, Sir, you begin to know how to set a right Value on the Convenience of living in Town; and am convinced that at present you would take more Pleasure in gratifying your Curiosity in the Shops of several Artizans, than at the Fair of *St. Germain*.

Chevalier. I should be particularly pleased with seeing how a Gilder makes a Vessel of Silver or Copper look like Gold, and gives the Appearance of this precious Metal to a Cornish or Festoon, without its being really such.

Prior. The Operations of this Art are very curious, but the Particulars of it are so many, and the Execution of it so very nice and delicate, that it is impossible to have a thorough Notion of it without seeing the whole Process of the Work. I will content myself with giving you a general Notion of it, though perhaps it may rather serve to excite your Curiosity, than satisfy it.

Gilders lay Gold either on Metals or other Materials; for which Uses they employ Water-Gold, or Leaf-Gold. When they would gild a Piece of Silver or Copper, they take a small Quantity of Gold dissolved in *Aqua fortis*, and reduced to a Calx. They put this Gold into a Crucible, and set it over the Fire, adding to it seven or eight times its own Quantity of Mercury: These two Substances amalgamate or mix together into a sort of thin Paste or butyraceous Matter, inclining to Fluidity: This they spread over the Plate or Vessel

Gilding.

Agricola Felibien.

Vessel which was prepared for this Operation, and then lay it on a Grate, near a very hot Fire; this done, the intense Heat of the Fire causes the Quicksilver to evaporate, the Gold which was absorbed in it remaining behind, sticking close to the Surface of the Metal: Last of all they wash it over with a red Colouring, in order to give the Gold a deeper Orange: And this they call Gilding.

When Gilders make use of Leaf-Gold, they either lay it on several Grounds or Layers of Glue and Colour, as in those Works which are designed to be within Doors, and under Cover; or else on the Remains of those Colours, and the Oil which they find settled at the Bottom of the Pot wherein they clean their Pencils, as in those Works that are to stand the Weather, and be exposed to the open Air.

Chevalier. It was a Remark of your own, Sir, that God had dispensed this precious Metal to us with a sparing Hand; though I cannot well see how this can be true, when Gilding is a thing so common every where.

Prior. Among other Perfections he has endowed it with those of Malleability and Ductility, which render it capable of having its Surface greatly enlarged; inso-much that, notwithstanding its Scarcity, Men may use it in Matters of Ornament, as if it were very common.

Gold-Beaters and Gold-Wire-Drawers make a great Shew of their Art, and we must confess it to be very surprizing, nay incredible, were not we Eye-Witnesses of it; however, we ought not to ascribe that entirely to their Skill, which is at the Bottom an Effect of the great Wisdom and Goodness of him who created this and all other Bodies. You may form a Judgment of the great Excellence and Ductility of this Metal, by one or two Operations it goes through.

A Gold-Beater melts three Ounces of fine Gold, and beats it on his Anvil into Gold-Beating. a Plate as thin as Paper; he cuts it with his Sheers into little Pieces about one Inch square; which he puts between the Leaves of a kind of square Book, which he wraps us close in a double Parchment Cover. He then with a great Hammer beats the Book upon a Marble

Marble Block, till the Leaves of Gold are beat out nearly to the Size of the Book; he then takes them out, cuts them in four, and places them again between Leaves of Parchment, repeating the Business of hammering and cutting several times. After they are brought to a certain Degree of Fineness in the two first Books, they are made to undergo the same Discipline in two others, which, as well as the former, are called Moulds; only they consist of Leaves, which, instead of Parchment, are made of Ox-Guts, wrought perfectly smooth and fine. By these means he hammers a little Plate of Gold, not more than one Ounce in Weight, into sixteen hundred Leaves three Inches square, or into a thousand square Leaves of four Inches; which gives it above a hundred and fifty thousand times more Surface than it had at first.

But the following Operation is still more surprizing, and not less common.

A Gold-Wire-Drawer takes an Ingot of Silver of a cylindrical Figure, two Foot eight Inches long, and two Inches nine Lines in Circumference, upon which he spreads as many Leaves of beaten Gold as weigh in all half an Ounce. They then force the Extremity of the Cylinder * through a round Hole made in a Plate of Steel, the Entrance into which is wider than the other Extremity, which they call the Eye †. When the Extremity of the Ingot or Wedge is forced through the Eye of the Hole, they lay hold of it with strong Pincers fastened to a thick Rope, which is haled in by an Engine turned by several Men. They then make the Silver to pass through several other Holes successively finer and finer, till by degrees they draw it out to the Smallness of a Wand, a Tag, a coarse Thread, and last of all to that of a fine Hair, rubbing it over with Wax every time they work it through a fresh Wire-drawing Iron, in order to render it more ductile. It passes through above a hundred and forty Holes, before it is brought to its utmost Fineness. Thus this little Ingot,

* Rohault, *Part 1. Ch. 9.*

† Boissard's *Treatise of Coins.*

not above two Foot some few Inches long, and two Inches round, is extended into a Thread 307200 Feet in Length; nay, they carry their Art still farther, and will draw out an Ingot two Foot long, and three Inches and four Lines in Circumference, into a Thread 1096704 Feet long, which, if extended in a strait Line, would reach from *Paris* to *Lyons*.

But the most wonderful Part of this Operation is, that the half Ounce of Leaf-Gold, which was at first laid on the Silver, should, notwithstanding its former Fineness, grow continually finer and finer as it passes through the several Wire-Holes; and yet so exactly cover the Silver-Thread, and diffuse itself in such an equal Proportion, as to make it appear like one entire Thread of Gold, and consequently stretch itself into a Surface above seventy-three Leagues long.

They afterwards press this Thread into a flat thin *Lamina*, by making it pass between two well-polished Cylinders or Rollers of Steel, that turn one upon another: The Thread being thus flatted, acquires two Superficies equally gilt, each seventy-three Leagues long; and consequently half an Ounce of Gold may and really does form a hundred and forty-six Leagues of Surface. If then Men, maugre the great Imperfection of their very best Instruments, can produce such surprizing Effects on the Works of God, how much more surprizing and excellent must the Works themselves be!

Chevalier. I am now fully convinced, that the internal Nature or Essence of this Metal, and perhaps of all other Bodies beside, is beyond the Reach of our Knowledge; and that we must at last have recourse to that Maxim which you taught me as an undoubted Truth, That the Works of Nature were given us not to be thoroughly comprehended by us, but to be used soberly and discreetly.

Prior. All the Disquisitions and Reasonings of Philosophers on the internal Structure of Metals, have never yet been able to give us any Satisfaction on this Point; whereas the Workmanship of a simple Mechanick is both amazing and useful. Wire-drawn Gold, as we have
already

already seen, is either plated or twisted; the Gold-Thread is the fine Wire, after it is plated, twisted round a Silk-Thread by a Spinning-wheel so as to cover the Silk entirely. The *Milaneſe* have the Art of ſaving half the Expence of Gold by a Secret which they have of gilding only the external Superficies of the Lamina that covers the Silk-Thread.

But the Effects of this Art are ſtill more ſurprizing in what they call counterfeit Work: In this Caſe the Ingot that is to be drawn out in Wire is of Copper, which they firſt overlay with Leaf-Silver, and then with Leaf-Gold; the reſt of the Operation is pretty much the ſame as in the fine Work. When it is drawn out to the Fineneſs of a Thread, they paſs it between the plating Rollers to be preſſed flat; after which they twist it, not on Silk, for that is prohibited, but round a Thread of Hemp or Flax, to prevent any Impoſition on the Buyer. Thus, you obſerve, there are three Strata or Layers of Metal drawn out into a fine Wire, without any Mixture or Confuſion of Subſtances; the Copper is the *Subjectum* or Baſis covered with Silver, as this is with the Gold.

Chevalier. Are all other Metals as ductile as Gold?

Prior. Not in the ſame Degree. The Ductility of Silver is very great, but leſs than that of Gold. This Property ſtill decreases more and more in Copper, Tin, and Lead.

Chevalier. Is there nothing particular worth obſerving touching the Origin of other Metals?

Prior. It will be worth while juſt to take a curſory View of them.

Pliny, ſpeaking of Silver Mines, ſays, that this Metal, when firſt found under Ground, has no Luſtre or Brightneſs, nor any particular Mark to denote its Species*. It is often found, it is true, in Marcasites, ſometimes of a reddiſh, and ſometimes of a bluish Colour, ſometimes in a ſort of Lead-Ore, from which they have found out the Art of extracting it: But in the Mines of *Potoſi* in *Peru*, as alſo in ſeveral others of *America*, and in the Silver Mines of *Germany*, this Metal is found ſparkling in the

* Nulla ſui ſpe naſcitur, nullis, ut in Auro, lucentibus Scintillis.

Mine, and easy to be discerned amidst the different sorts of Earth in the Fissures and Strata of Rocks. Sometimes they find it dispersed in Stones, or adhering to the Out-sides of them, branching out in Threads, Fibres, and several little Ramifications, from which Forms it has obtained the Names of *Argentum capillare, fibrosum, &c.* † Nor is it a rare thing to find Silver in little Masses, consisting of small Filaments or Threads, like a Ball of Silver-Thread burnt: And lastly, it is sometimes found in pure solid Masses, weighing a Dram, an Ounce, and sometimes several Marks. In the Reign of the Emperor Frederick III. there was found in the Mine of *Schneeberg*, belonging to the House of *Saxony*, a Block of Silver of a most prodigious Size. Duke *Albert* had the Curiosity to go down into the Mine to see it, and ordering the Cloth to be laid upon it, said to those who sat down to Meat with him: *The Emperor Frederick is indeed a powerful Prince, but you must allow that my Table is of more Value than his* *. It cannot be thought unreasonable, or foreign to the Subject in hand, to remark, that in Silver Mines are often, and more commonly than any where else, found what they call *Marcasites*, which are Masses of a stony Substance, streaked with metallick Veins, generally ranged in the manner of so many Radii, uniting in one common Centre. The particular Formation of these Stones (which I purposely deferred speaking of, till I came to the Subject of Metals) seems to be thus: When a little Mass of Earth mixed with Iron or Copper happens to be covered with a vitriolous Water, in which is a Solution of some Silver, the Acids of the Menstruum insinuate themselves into the Pores of the Iron and Copper, and flow in strait Lines to the Centre, like so many Streams into a common Receptacle of Water, leaving the Particles

† See Woodward's Method of Fossils, p. 49.

* The Baron of *Puffendorf*, in that Part of his Introduction where he speaks of the House of *Saxony*, reckons the Weight of this Mass of Silver, at four hundred Quintals, or forty thousand Pounds, the Quintal weighing a hundred Pounds. But *Agricola*, who was an Author of great Judgment and Credit, and wrote in that very Place two hundred Years ago, and presently after the Death of *Albert*, says, that he never met with any Person that remembered the particular Weight of this Mass: *Ponderis illius Massæ qui meminisset audire neminem.*

of Silver behind them, in the little Guts or Channels through which they passed, in the Form of so many Radii, or strait Lines converging to the Centre of the Mass; when these little perpendicular Streams branch out into small Divisions, the Marcasite then appears veined with little irregular Fibres of metallick Matter in all Directions. The Superstructure of the Marcasite being thus begun; if the Mass is afterwards surrounded by another Menstruum, in which there is a Solution of some other Metal, the Acids of the new Menstruum do in like manner insinuate themselves into the Pores of the former Mass, introducing with them those metalline Particles, whether of Copper or Iron, with which they abounded; whence it necessarily follows, that the Radii which tend to the Centre of the Marcasite are intersected with Lines of different Colours, denoting the different Fluxes of the metalline and other Matters that form those little Coats or Teguments which invest the Mass, and give the Marcasite its gradual Increase.

Let us next examine how the Silver is extracted from its Marcasite, and its common Ore.

Now this Separation is effected in Silver nearly the same way as in Gold. They break the Ore in the Stamping-Mill, till it is reduced to Powder; they then mix it up with Mercury into a sort of Paste, which they knead in the Troughs till the Water has by degrees washed away all the earthy Particles: After this they strain off Part of the Mercury from it through a woollen Bag, to serve again, and the rest they make to evaporate by Fire. The Silver that remains behind is, last of all, perfectly refined from what heterogeneous Matter is left, by a Solution of Lead; which exhaling from it, carries off in Fumes the Copper or other Allay, that remained in the Silver.

The Proportion which the Weight of Gold bears to that of Silver is as eleven to twenty; that is to say, if a cubick Mass of Silver weighs eleven Marks, a cubick Mass of Gold of the same Dimensions will weigh twenty Marks. The Proportion betwixt the Value of these two Metals is nearly as one to fourteen:

The Proportion
betwixt Gold
and Silver.

fourteen; so that if a Mark of Silver is worth, for Example, fifty Livres, a Mark of Gold will be worth fourteen times as much, or seven hundred Livres. But the Value of these Metals is arbitrary, and depends upon the sovereign Will of the Prince.

I need not take up your Time in expatiating on the Uses Silver is put to, since every one knows, that of all the Metals that constitute the chief Riches and Possessions of private Persons, this is the most noble, the most wholesome, and most durable.

Copper is of two sorts, red and yellow. When it is first taken out of the Mine in its Ore, whether of Earth or Stone, they sometimes find in it an Admixture of Silver: They purify and separate it from all extraneous Matter, by frequent Fusions over the Fire, and then it becomes what we call red Copper: This is the purest and most ductile. Almost all Countries do abound with this Metal, but the best comes from *Sweden*. A Mass of Copper fused with an equal Quantity of Calamine, or *Lapis Calaminaris*, (which is a sort of Cadmia or Fossil Earth purified in the Fire) will thereby be considerably augmented in Quantity, and become by this Operation yellow Copper or Brass. This Alloy does indeed render the Metal less ductile, but much more proper for several Uses, and less subject to Rust. They have also the Art of restoring to it its Ductility, by softening it with an Admixture of Lead.

Copper.

Red Copper.

Yellow Copper
or Brass.

Chevalier. As Gold and Silver is now become somewhat more plentiful by the Discovery of the Mines in *America*; and since the Fashion of *China* and *Delft*-Ware has so universally prevailed; I am told that the Use of Copper and Tin is almost entirely laid aside.

Prior. It is true, they are not so commonly used in the Service of the Table as formerly; but there are, notwithstanding, a thousand other ways of employing them to Advantage, and wherein they are of necessary Use to us.

Both red and yellow Copper are the Materials of which Cisterns, Coppers, Caldrons, and others Vessels so necessary in Dying, Brewing, and other Trades, are generally made: nor could we be supplied with Pots, Kettles, and other Furniture proper for the Kitchen, without them. But as the Nitre which is in the Air (especially when diluted and attenuated by Heat and Moisture) does by insinuating itself into the Copper, which is very porous, corrode the Metal, and adhere to it in the Form of a Rust or Crust called Verdigrease, which is a deadly Poison, they are wont therefore, by way of Precaution, to tin over the Insides of most of our Copper Vessels, especially those that are made of red Copper, as being softer, and consequently more liable to Impressions of this Kind; for the Tin being of a more fluid and subtle Nature than the Copper, closes up the Pores and Interstices of the Metal, and hinders the Air and the Water from depositing their Salts within them. Red Copper is also, by reason of its great Ductility and Malleability, easily wrought into any Shape or Figure that the Artist is pleased to impress upon it; but this Metal is most eminently useful in

Chalcography.

Chalcography, or the Art of Engraving, as it thereby serves to propagate the Works of famous Sculptors and Painters. A very

indifferent Copy of a fine Picture shall stand us in ten Pistoles, when for the same Price we may purchase thirty curious Prints, which, except the Colours, shall express all the chief Beauty (which is the Design or Fancy) of the Originals: Nay, we sometimes find the Pencil outdone by the Graver: Mr. *le Brun* is indebted to Mr. *Gerard Audran* for no small Share of his Fame, and Mr. *Cachin* has now-and-then improved upon the Painter by adding some enlivening Grace or masterly Touch of his Art. Nor is the Art of engraving only confined to that single Province of propagating the Performances of those who have excelled in Painting, but daily produces great Masters, and affords new Scope for Invention: And as nothing did ever advance the Progress of Learning and Science, so much as the Invention of multiplying the Copies of Books by the Assistance of Printing-Types; so never did any thing more improve or encourage the Art of Sculpture, than that of engraving on Copper Plates,

by supplying us with the best Models of all kinds for our Imitation at so easy an Expence.

Yellow Copper or Brass, which by reason of its Mixture with the *Lapis Calaminaris* is more fusible than malleable, is used chiefly in Cast-work, it being very susceptible and retentive of all the Impressions of the Mould; it afterwards undergoes the Discipline of the File and Graving-Tool, and when polished with Emery * or Putty, or otherwise burnished, will glister like Gold. Thus Copper is transformed into Statues of all Sizes, or converted into Ornaments for the Decoration of Cupboards, Chests of Drawers, Clocks, &c. in the Form of Palms, Festoons, Chaplets, and a hundred other pretty Embellishments: And forasmuch as this Metal is not only easy to be worked, but also Proof against Rust, and all other Injuries from Time, they make of it Lamps, Sconces, Candlesticks, and Supporters of all kinds: Its Durability was the Reason why the *Romans* formerly made the Gates of their Temples of Brass, and we at this time use the same Metal in those magnificent Ballustrades which rail in the Choirs of our Churches, and the Beds of our Princes. Perhaps all *Europe* cannot afford any Work of this kind, which, for Art and Grandeur, can vie with that famous seven-branched Candlestick, the vast Expence of which gave so much Offence and Occasion of Censure to St. Bernard †, and which the Curious resort so much to see in the Choir of the Abbey of St. Remi at *Rheims*. This Metal is also used in decorating the Frames of Pictures, in making Snackets for Casements, Hinges, and in all the curious Parts of the Locksmiths Business, though Brass-Work of this kind is more used among the neighbouring Nations than us. They further make of it Compasses, Quadrants, and all sorts of Rules for Geometers; Astrolabes, Spheres, and other Instruments for Astronomers; Plates, Wheels, and other Movements, for Clocks and Watches. This last kind of Mechanism will sufficiently prove to us the Excellence and Usefulness of

Brass.

* Emery is a mineral Stone or Marcasite, which they reduce to a very fine Powder in the Steel-Mills, and use in polishing Marble, and Metals. Putty is calcined Tin used for the same Purpose.

† *Apelegia ad Guillelm. Abb. c. 12.*

this Metal: Two or three Ounces of Brass with a few Rivets of Steel are made to form a Machine consisting of two hundred different Pieces, (which we call a Repeating-Watch) and all within the Compass of a Case not more than one Inch deep, and two Inches in Diameter: And what is still more surprizing, the Teeth of the Wheels which compose this little Engine, though almost imperceptibly fine, have sufficient Strength and Solidity to continue in Motion for 60 or 80 Years without wearing out, and serve all the while, both Night and Day, as a faithful and unerring Monitor of the Time.

By mixing equal Proportions of the red and yellow Copper together, we form a mixed Metal, which we call cast Copper (in *French Bronze*); a Matter very proper for the Purpose of perpetuating the Memory of famous Men, and remarkable Occurrences. This Metal they used in all Ages of the World whereof to make their current Coins, which being transmitted down to Posterity, and having

Medals.

gained the venerable Stamp of Antiquity, we call Medals, which are so carefully collected by the Curious; nor are they only to be valued as Curiosities, seeing they are useful to us in the Study of History, and serve to imprint the Memory of Persons and Facts more deeply in the Mind, by giving us sensible Representations of them. We can therein trace Antiquity in the just Order and Course of Times, and without disgusting the Memory with a long dry Series of Dates and Names, see and learn at one View the Successions of Consuls, Emperors, and Kings, their Names, Features, and Actions; as by walking frequently in a great Town we easily remember the Order of the Streets, the Persons, Names, and Trades of its Inhabitants. But it is just in the Case of Medals as in Mathematics and the Languages; these Parts of Learning being no farther serviceable, than as they are applied to some more useful Design and Purpose: To what Purpose do we draw Geometrical Schemes and Lines upon Paper, but to apply them in measuring Land, or on some other practical Occasion? Wherein lies the Use of *Hebrew*, but in the Study of the Scriptures? And what Benefit can be reaped from a great Collection of Medals without applying them to that of History? Without such an Application

of them, would it not be full as reasonable to treasure up a great Bundle of Keys without any Design to fit them to Locks, and to open Doors with them? But this Metal does still serve in a more conspicuous manner to do Honour to the Memory of departed Kings and Heroes, and to preserve their Portraitsures; they having brought the Art of melting Metals to that Perfection, as to be able at one Cast to form a Colossus, or an Equestrian Statue bigger than the Life, in order to proportion them to the Magnificence of those spacious Squares and publick Places where they are to be erected.

If this Metal be mixed with a little Tin and Antimony, to make it fuse the better, and consequently to consolidate afterwards with greater Tenacity and Coherence, it then becomes fit for the Casting of Cannons, Mortars, and all the murdering Implements of War. By fusing it with a double Quantity of Tin, that is, by adding twenty-five Pounds of Tin to a hundred of cast Copper, it becomes very sonorous, and is used by the Founders in casting of Bells, the Sound of which is so great as to be heard farther than the loudest Trumpets, and therefore were made choice of as the most proper Monitors to give Notice of the Times of publick Worship, and to summon all Christians to assemble together in their respective Churches, as also to proclaim the Anniversary of Holy-days and Festivals, and to animate our publick Thanksgivings and Rejoicings on proper Occasions.

What we have hitherto remarked on the Nature of all these Metals, and on the Manner of extracting them pure and clean from their Ores, by the Operations of the Water and Fire, is also applicable to Tin and Lead. Tin is originally nothing but a kind of white Lead, and, like it, soft, ductile, and very ponderous. Its Properties and Uses vary by being mixed with other Metals, as with Copper or Brass; or with other metallick Matters, as Zink and Bismuth,

Tin.

Lead.

Bismuth.

Zink.

Experience has taught us to mix and temper these Matters so together, as to make of them all sorts of Measures and Vessels, and to tin over the Insides of our Copper Vessels, which would otherwise soon be corroded and infected with a poisonous Nitre. They spread a Composition of Tin and Quick-Silver over the Reverse of our Looking-Glasses, to make them reflect the Rays and paint the Objects more distinctly. It is to a due Mixture of Tin and Lead that we owe the Formation of the Organ, that heavenly Musick, which, for its Majesty and Length of Sound, its delightful Harmony, the Variety of its Notes, for the Art of soothing the Passions, and tuning the Affections of the Soul, and, in a word, for taking in the whole Compass of Musick, surpasses all other Instruments.

Lead wrought into thin Plates or Sheet-Lead. Laminæ, either by the casting Furnace, or by that ingenious Invention of the plating Mill, is made use of for making Pipes for the Conveyance of Water, Cisterns and Reservoirs for containing it; for making of Gutters and Drains for the Preservation of Timber-work, Walls, and Terrases, and for overlaying Churches and other great Edifices, to secure them against the Injuries of Time and Weather.

But the chief Merit of the Composition of Lead and Tin, is its being used in casting the Printing-Types. Types or Characters of Printers, where-with they so speedily multiply the Copies of the same Book, and which being again distributed into their Boxes, serve to do the same Office to several others; a Discovery highly important and beneficial to Mankind, as it serves to bring us acquainted with Antiquity, and the Opinions of all learned Men that have gone before us, on all Subjects whatever. After this short Account of Metals and their Uses, pray, which of them do you think we are most indebted to, all things considered?

Chevalier. What room for Doubt in this Case? Can any of them dispute the Preference with Gold?

Prior.

Prior. I will retract none of those Praises which I have bestowed upon Gold; for it is unquestionably the most perfect of all Metals: nor is it my Design to depreciate any of the others, seeing they have all their respective Qualities and Uses to recommend them to us; but, after all, that which seems to be the vilest and coarsest of them all, which is the fullest of Alloy, of the most dirty Colour, and the most subject to Rust, in a word, Iron, is of most real Service and Advantage to us. It has one Property, which, in some respect, is alone sufficient to give it the Preference over all other Metals, it being the most hard and tenacious of all, and when tempered (which is done by dipping it hot in cold Water) it acquires a still greater Degree of Hardness, and fit for the most durable Uses. By this Property of resisting all Impressions, it becomes the Security and Defence of our Houses, and the faithful Depository of every thing we hold most dear. By uniting and linking together the Materials which compose our Buildings, it shelters us from the Inclemency of the Weather, and protects us against the more injurious Attacks of Thieves and Robbers; nay, our very Jewels and Gold would not be safe but for the Custody of Iron: To this we owe the chief of those Instruments which are used in Navigation, Agriculture, and all the Arts both Liberal and Mechanick, whether in separating or joining together, in digging, cutting, filing, polishing, and in making all the Conveniences of Life. Gold and Silver, as well as other Metals, would be in a manner useless to us, had we not Iron to work and fit them for our Occasions; and, to sum up all, so much are we beholden to this Mineral, that without it our very Meat and Drink could not be conveniently dressed and prepared, nor the Furniture of our Houses, nor the Utensils of our Mechanicks, be in any tolerable Degree serviceable. Hence you may be able to form a pretty exact Judgment of the superior Excellence of Iron over all other Metals; the latter are extremely useful, the former is absolutely necessary.

Chevalier. I have sometimes thought it a great Instance of Ignorance and Simplicity in the Inhabitants of the new World, [*America*] to give our Merchants (as they often do) a pretty large Quantity of Gold, in Exchange for a Hedging-Bill, a Spade, a Mattock, or some other Iron-

Tool; but I begin now to have a better Opinion of their Understanding, seeing Iron is of more real Service and Benefit to them, than their Gold can possibly be.

Prior. You see, my dear *Chevalier*, that Man can neither lift up his Eyes to Heaven, nor take a Step upon the Ground, nor dig under his Feet, without encountering Treasures designedly placed there for his Use: Every thing he sees within the Circuit of the whole Creation, may serve to convince him how much he is the Object of the Goodness, and tender Regard of his Creator, who not only foresaw, but has made Provision for all his Wants, and who has spared no Means, that might either excite his Industry, or engage his Affections.

But the gracious Designs of Providence, so visible in the many excellent Properties of those Metals which it has lodged in the Bowels of the Earth for our Use, are still more conspicuous in that exact Proportion, which it has fixed between the Quantity of them and our Wants. If a Man had been invested with full Power and Commission to create Metals, and to furnish Mankind with such Supplies of them, as he should think proper, he probably would be more profuse of his Gold than of his Iron, and look upon it as the greatest Instance of Generosity, and a publick Spirit, to give us most plentifully of that Metal, which we most covet and admire: whereas God has wisely acted by a contrary Rule; and so farasmuch as the chief Worth and Excellency of Gold arises from its Scarcity, he has therefore given it to us with a sparing Hand: and though the Frugality of this Dispensation is made matter of Complaint by some ungrateful Persons, yet it does in Reality enhance the Value of the Blessing. On the other hand, Iron being of such necessary and universal Use to us, he has every where supplied us with it in great Abundance. We see here no Ostentation, nothing but pure and perfect Beneficence flowing, not from any Design of procuring vain Honour to the Giver, but real Good, and solid Advantage, to the Receiver.

If then Providence, which is ever watchful for our Good, has best promoted the Interest and Welfare of Society, by the present wise Distribution of Metals, and the Proportion which it has established between their respective Quantities and our Necessities, what else can we

call

call any Design to increase the Quantity of those which were for good Reasons given us in less Abundance, than an Attempt to subvert that Order and Oeconomy, which God has already appointed?

Chevalier. According to your Doctrine, Sir, the Art of making Gold, and the Study of the Philosopher's Stone, which makes so great a Noise in the World, are unlawful Things.

Prior. I don't say that there is any express Law, either natural or revealed, against making Gold, any more than against making a Journey to the Moon.

Chevalier. You seem by your Comparison, to think the one as impossible as the other. But whatever your Opinion may be of the Matter, I have often heard a Story related of a tall, meagre Man, in a very mean Dress, who being taken in one Evening, and lodged by a Gentleman, whose Name I have forgot, out of mere Charity, saved the Life of the Master of the House, who lay at the Point of Death, and restored him immediately to a State of perfect Health, by means of some potable Gold, to the great Surprize of the Family, and of the Physicians, who had given him over; and moreover, that our Traveller the next Day converted a great many Pewter Dishes and Tin Pots into Gold, before he took his Leave, and was never seen afterwards. Here is an attested Matter of Fact, to prove that this Art is no Chimera.

Prior. No wonder that this and such-like marvellous Stories gain Credit with some sort of People, seeing there are in every Place those who are credulous enough to believe any thing they hear, and vain enough to take a Pleasure in appropriating it to the Place where they live. There is scarce any Country that does not vouch this Adventure of the tall, meagre Man, to have been transacted there. Your Province lays Claim to it; and I have heard it at *Roban* told with all imaginable Seriousness. The *English* ascribe it to their *Philaethes*, and all the *German* Chymists give their own Nation the Credit of it. This Story of the meagre, ill-favoured Man, who had the Art of making others plump and healthy, while he himself was but a mere Skeleton, sounds full as absurd as that which they tell you at several Inns, of a

The Vanity of seeking the Philosopher's Stone.

Passenger,

Passenger, who once upon a time happening to lie there, and not having Money to pay for his Supper and Bed, he, to make the Host amends, converted a Brass Candlestick and a Dish into Gold. These marvellous Things are related in so many different Places, and all laying Claim to them, that it is a plain Confirmation they never happened at all. One natural Argument will suffice to shew the vain Pretences of making Gold by Art. Those who have passed for the greatest Adepts in this Mystery, have laid down very plain Receipts in their Books on this Subject, both how to convert other Metals into Gold, and how to extract the scattered Particles of Gold from the less perfect Metals to great Advantage; but after ten thousand Experiments most faithfully executed, according to these Directions, they have always failed of Success; and though they have been always near the Mark, as they pretend, yet they could never yet hit it; or if at any time they so far succeeded, as to find a little Gold at the Bottom of the Crucible, secreted from other Metals, yet the Quantity was so small, that it did not near answer the Trouble and Expence, nor give any Encouragement to repeat the Operation. A great Number of Princes, Nobles, and Chymists, in all Countries, have, for several Centuries past, been in search for this Secret: Vast Sums of Money have been advanced, and numberless Experiments been made, in order to a Discovery; but, after all, the most experienced and judicious of them, even the *Hamburghers* themselves, have confessed that they lost both their Learning, their Labour, and their Money, without making any Discovery, or, at best, without finding what they were in quest of. Now if the Art of making Gold had been possible to arrive at, it is natural to suppose, that what they could not discover from any certain fixed Principles, they might at least, in the Course of so many Millions of Experiments, have hit upon by Accident: And yet after so many Books as have been written, so many Questions debated, and so many Operations performed in vain, on the Subject of extracting Gold, and the Transmutation of Metals, we daily find People who busy themselves in the Pursuit of this great Work; but never yet could say, *There goes the Man who has found it*: Nay, six hundred Years Labour and Study have not yet produced

produced any regular Method or probable Scheme to proceed upon, and we generally find that all our philosophical Projectors in this way first ruin themselves, and then draw in some wealthy Persons or orther, who are Dupes enough to advance Money till they share the same Fate. The thing is absurd at the first Sight; for had they found out the Secret, what Occasion to be obliged to the Rich for their Assistance? If not, what can we call it less than Madness and Infatuation in the latter, to give any Credit to them, much more to risque their Fortunes in an Undertaking so extravagant, and always hitherto unsuccessful? The utmost Favour we can possibly allow them is to say, that they are grossly imprudent, and fondly credulous.

We may, it is true, by a Mixture of metallick and other Matters, produce a Metal different from all others, as Bismuth, Bath-Metal, or Princes-Metal; as by adding Water to some good wholesome Fruits, or by mixing different Liquors together, we may make one which may seem quite new; but as we can never hope to make Cyder or Wine, without the Juice of the Apple or the Grape, so is it in vain to attempt to make such a particular Metal as Gold, without knowing the Nature and Essence of those first Principles that compose it; nay, were we as much acquainted with, as we are at present ignorant of them, yet the manner of uniting and combining these Principles together, would prove an Operation surpassing our Skill.

Nor is it without wise and good Reasons that Providence, which created these Metals, and whatever else we see, thought it sufficient for us to know the Uses they were designed for, and therefore concealed their Essences from us; for had it given us a perfect Knowledge of their Natures as well as Uses, it would have made us inattentive to every thing else; instead of applying Gold to those Purposes for which it was created, we should busy ourselves in making it, and render vile, by making too common, what was before chiefly valuable for its Scarcity: We should break in upon that Order and Oeconomy which Providence has established in the World, and defeat that wise End which it proposed by making Gold the Product of one Country, Silver and Diamonds that of another, and salutary Fruits that of a third; for had we the Art of making Metals, the same Degree of Knowledge would

suffice to make precious Stones, would put us in a way how to make Wine (by mixing and proportioning those Principles of which it is composed) without waiting for the Return of the Vintage; we should think it beneath us to stand indebted to the common Course and Order of Nature for what we needed, by those ordinary Methods of Husbandry and Agriculture, having the Means of providing ourselves, at all times, with those Necessaries and Conveniencies of Life at home, which are now the Productions of different Countries, and certain Seasons. Were we thus perfectly skilled in all the Secrets of Nature, and Masters of all its Powers, there would be an End of all Commerce, and we should scorn to be obliged to the different Seasons of the Year, for ripening the Fruits of the Earth, or to the Service of our Fellow-Creatures in gathering them; thus the very Bonds of Society would be broken, and the Inhabitants of the whole Earth be like so many recluse Philosophers, having all things within themselves, and independent one of another; and consequently all Intercourse of Friendship and mutual Kindness would cease, Men having no longer Occasion for any Exchange of Civilities and good Offices; nay, there would not be any Opportunity or Room for the Exercise of Justice, Prudence, Compassion, Courage, or Good-nature, according to the different Circumstances of Time, Place, and Person: In a word, a more extensive Knowledge would necessarily be attended with the Loss of those Virtues, which, together with our mutual Wants, constitute the very Life and Soul of Society.

Chevalier. After the full and particular Account you have obliged me with, of those immense Riches which were created for our Use, and left at our Disposal, I find myself affected with the highest Gratitude and Admiration at that Profusion of Blessings which have been poured down upon us, and am far from complaining on account of those things which are denied us; being fully convinced, that we stand no less indebted to God's gracious Goodness, for what he has thought fit to refuse, than for what he has been pleased to grant us.

USEFUL
REFLECTIONS
On the WHOLE:

In a LETTER from the PRIOR to
the CHEVALIER.

S I R,

SINCE your Departure for the Sea, I have revised, according to your Desire, the Collection of our Remarks on the Survey of Nature. This Perusal gave Birth to some new Reflections, which I shall here impart to you; and also gave me an Opportunity of setting some Passages (which seemed to me to require it) in a clearer Point of View, and which you will find referred to in the Margin of this Epistle.

Hitherto, my dear Chevalier, we have been more intent on contemplating our Riches, than on considering the Uses to which they ought to be applied; I having rather set before you the Extent of your Possessions, than the Intentions of him to whom you stand indebted and accountable for them: And this Method of proceeding is much more reasonable than it appears at first to be. The Author of Nature has been pleased to discover himself to Man chiefly, in the Manifestations of his Works, and to bring him to the Knowledge of his Divinity, and to engage his Affections by the most endearing Methods of infinite Bounty and Condescension: It is therefore agreeable both to the Intentions of God, and to the Order of his Providence,

Providence, to begin with taking a Survey of those Benefits which are the free Gift of his Goodness; and if these Considerations fail to lead us to the Knowledge of him who is the great Author of them, we shall stand convicted of a most criminal Inattention, and unpardonable Ingratitude. Let us therefore complete what we have begun, and, after having taken a Prospect of the Works of Nature, direct our Thoughts to that particular End, for which the Beauty, Order, and Riches, which adorn the whole Circle of the Creation, were appointed.

Were a Savage of *America* possessed of a Watch, and had, by frequent Observations on the Movements, attained to a thorough Knowledge of the Action of the Wheels, the Disposition and Correspondence of the several Parts of it, without knowing the Division of Time, or any Use of his Watch, he would in Reality be more ignorant, with regard to all the Intents and Purposes of this Machine, than an *European* who knows how to inform himself by it of the Time and Hour of the Day; without having made any Observations on the Mechanism and Structure of it. Just so it is with him who has spent his Life in the Study of Natural History, and taken no Pains to acquaint himself with the Ends and Designs of Providence in the Oeconomy of the World. This Philosopher, notwithstanding all his Study and Learning, is more devoid of true useful Knowledge than the illiterate upright Man, who, without having made any curious Researches into the Laws of Motion, or the particular Structure and Frame of the universal System, sees enough to lead him to pay his constant Adorations and Thanks to that great and good Being, who created and sustains this wonderful Machine for his Use, and continues to shower down daily his Gifts and Blessings on Mankind. We may then collect and treasure up Rarities from the four Quarters of the World, cast up the Number of the Stars, calculate the Motions of the Planets, and venture to foretel the Return of Comets; we may be able to dissect Insects with all imaginable Art, and anatomize the Elements themselves, and even trace Nature through all its curious Phænomena, and yet remain profoundly ignorant. The whole System of Nature may very aptly be compared to a large Watch, the Springs and Movements of which are employed to

teach

teach us something more than is visibly represented by them; and therefore the Naturalist who spends his whole time in barely observing the Play and Action of these Movements, without carrying his Inquiries farther, is no better than our *American Savage*; he labours to find out what is not necessary for him to know, and perhaps impossible for him to comprehend, and neglects the only main Point, which is to know what the Watch is good for.

What then, shall we say, is the Use and Design of Nature? Shall we compare it to a Looking-Glass, which is made to represent something more than the Glass itself, or to an Enigma, which under remote Similitudes and Terms conceals some Meaning, which we are glad to find out? This is the most adequate Idea we can frame of it. Both Reason and Religion conspire to engage our Attention to the Language of the Heavens, of the Earth, and of the whole Universe, which with one common Voice proclaim the Glory of God from one End of the Creation to the other; they clearly point out to us his invisible Perfections in the visible Operations of his Hands: The Prospect of Nature then is a kind of vulgar Theology, in which all Men may learn those Truths which it is of the highest Consequence and Importance for them to know.

Psa'm xix.

Rom. i. 20.

The first Use which a great Number of learned Men have thought fit to make of Natural Philosophy, has been to prove the Existence of God; but however laudable the Design of these Men may seem, in being at the Pains to deduce from hence regular Demonstrations of his Being, yet I cannot help thinking such a Labour useless and unnecessary. Who ever thought it worth his while to draw out his Watch to prove that there is such a Trade as Watch-making? Who ever saw a beautiful Machine, and doubted at the same time whether it was contrived by some skilful Artist? There is no Occasion for any Force of Argument to shew the necessary Connexion of these two Ideas; and were any Man to dispute whether my Watch had a Maker, I should not think it worth while to convince him. The many large Volumes which have been written to prove the Existence of God, of which

which every reasonable Man is as thoroughly convinced as of his own; the many Sermons and Theological Lectures, which are founded in some Countries to establish this Truth, which common Sense will teach every Man, are so many Discourses, in some sort, affronting to the Understanding of their Auditors and Readers, at best unprofitable and needless; seeing the Authors of them suppose that there are such Persons as Atheists, when there really are none; or granting this, they are addressing to the Reason of those who are resolved not to be convinced, and therefore undeserving of such a Compliment.

If the whole World is, as must be granted, one great Picture, in which are displayed the Perfections of God, the Use of this Representation is not to prove to us that he is the Author of it, but to demonstrate his Unity, his Power, his Wisdom, his Independence, his Goodness, and his Providence. It is, as it were, an agreeable School, where we need only open our Eyes, and receive Instruction, and where Truth even prevents our Inquiries, by presenting itself to us in so visible and inviting a Dress, that it cannot fail to charm its Beholders.

The Principles of Natural Religion.

The Unity of God proved from the Union and Harmony of all the Parts of Nature.

The Unity of that first Principle which created the Universe, demonstrates itself to the Senses of all Men, in that Harmony and Union, which they cannot but see in all the Parts of Nature; in that one simple End to which it is directed; and in the Uniformity of those Means which conduce thereto.

Which way soever we direct our Observation, we discern either simple Elements or compound Bodies, which have all different Actions and Offices; what the Fire inflames, the Water extinguishes; what one Wind freezes, another thaws; and what the Sun dries, the Rain moistens. But all these Operations, and a thousand others, so seemingly repugnant to each other, do all concur in a wonderful manner to produce one Effect: Some serve to assist, some to qualify and correct the Violence of others, and are all so necessarily useful to carry on the main Design, that were the Agency of any one of these Causes destroyed, the Ruin of the Whole,

or

or at least an Interruption of the Order and Harmony of the Creation, would immediately ensue.

Let us suppose taken away, for Example, the Wind or Agitation of the Air, which, of all the Phænomena in Nature, seems the most accidental and fortuitous; and behold! all Society and Nature are in the utmost Disorder and Confusion; Navigation is at a Stand, and all Commerce with foreign Nations intirely put a Stop to: On the other hand, the Vapours which are raised from the Sea by the Heat and the Air, would remain suspended and immoveable over those Places from whence they were first exhaled; for want of Motion in the Atmosphere to disperse the Clouds over the Earth, we should be deprived of that useful Covering, by the Interposition of which we are now skreened from the Summer's scorching Heats; our Lands would be parched up; the Fruits of the Earth wither; the Animals die for lack of Moisture; and all Nature would languish and droop.

But instead of the Wind, the useful Effects of which are so apparent, let us suppose ourselves deprived of only one particular sort of Earth, which we don't seem to stand in such absolute need of, the Clay, for Example; and see what would be the Consequence of such a Deprivation. Now the Inconvenience which would arise from hence, would not be less than the foregoing: For besides the Loss, which more than two thirds of Mankind would sustain, for want of those proper and necessary Vessels which are made of this Earth, we should be deprived of those more important Benefits, which we receive from our Wells, Springs, and Rivers. The Circulation of Vapours and Waters, it is true, would not be impeded thereby, but they would cease to be of any Service to us. The Vapours condensed into Rain, would soak through the Mountains and Plains, down into the Bosom of the Earth, for want of Strata of Clay to stop and detain them; or would work their way through subterraneous Passages into the Sea, without yielding us any Benefit.

As all the Parts of Nature therefore were constituted for the mutual Service and Assistance of each other, so do they undeniably prove the Unity of their Omniscient Creator. If one Almighty Being had created the Sun, and another the Earth, as the Views and Ends which they

they proposed by these Acts of Creation would be different, he that made the Sun would not submit that so glorious a Body should be intirely subservient to the Use of the Earth, and consequently they would be like the fabulous Deities in *Homer*, always at Variance: The Order and Government of the World do therefore necessarily suppose one only first Principle, who has established such a Correspondence between all the Parts of it, and made them so dependent on each other, that the Annihilation or Subduction of any one of them, would destroy the Beauty and Oeconomy of the whole Machine, and superinduce an universal Disorder.

From the general End of the whole System of Nature.

The same Truth receives still stronger Confirmation, when we reflect on the general End to which all the Parts of Nature are directed. It could only be one, and the same intelligent Being who has impressed upon them all the same Tendency, and has used the Concurrence of so many different Causes and Actions to produce one Effect. In my Letter to you on *the Extent and Bounds of Reason*, I believe I sufficiently convinced you that Man is the Centre of all the Works of God, and that if we exclude him from the Creation, whatever Beauty and Comeliness is in the World would no longer serve to any beneficial Purpose. We proved in our subsequent Discourses, that whatever is produced on the Surface of the Earth, or formed within the Bowels of it, is for the Use and Service of Man. The same beneficent Intention appears throughout the whole, and universally proclaims the Unity of our common Benefactor.

This Truth has been contested by some scurrilous Poets, and more contemptible Free-Thinkers: But it is not my Design to follow them through their profane Jest, and impudent Raillery, being fully convinced that those whom God cannot bring to a Sense of his Perfections by the Mercies he vouchsafes them, we must not expect to make Converts by the Force of our Arguments.

Nor is the Supposition of a Plurality of Worlds, as some imagine, any Objection to this Doctrine; for were it true, as the Abettors of this Hypothesis maintain, that the Planets are so many Earths enlightened by the Sun, and

and peopled with other Inhabitants; and the Stars so many Suns illuminating other Planets, which have in like manner their respective Inhabitants; it would only follow from hence, that God has in other Parts of the Creation displayed his Wisdom and Power to Beings, whom he has made the Objects of his Care in each habitable Sphere, as he has us in this: Nor would it be on that account less certain, that all those vast Bodies, which move in their proper Orbits, in so much Harmony and Order, were all created by the same Hand, and are subject to the Laws of one and the same Master. The many Groupes of Figures in a Picture do not prove against the Unity of the Design: And the several Parts in a Concerto do rather more strongly prove it to be the Composition of one skilful Musician.

The Unity of the Creator of the Universe does still more evidently demonstrate itself in the Propagation of Plants and Animals; for since each particular Species in both does always propagate its Kind under the same Figure, and with the same Properties, it is evident that every Species was formed upon one and the same Plan; and the Unity of the Plan does undeniably prove to us the Unity of that intelligent Being that formed it.

From the Generation of Plants and Animals.

All the different Species of Animals and Plants, so wonderful in their Number and Variety, do also give us concurrent Evidence of the Unity of their Author, by the uniform Manner in which they are perpetuated. We shall not enter into a Discussion of the several Opinions and Disputes of Philosophers, concerning the Manner how the Eggs and Seeds of Animals and Plants come by their Fecundity, but confine our Attention a little to what is confirmed by repeated Experiments and Observations.

Every Animal, both small and great, is produced originally from an Egg, in which it was contained; and every Plant from a Seed wherein it lay concealed in Miniature. When the Animal breaks loose from its Cell in its perfect Form, we Part I. Dial. I. say the Dam of it is viviparous; when the young is excluded with a hard Covering round it, which we call the Shell, we say that the Dam is oviparous.

parous. The Shell of the Egg in the oviparous Kind is hard and convexed, the better to resist the Pressure and the Injuries of the Air to which it must lie exposed for some time; whereas this Precaution would be of no Use in the viviparous Kind. Thus does even the Diversity of the Work prove the Unity of the great Artificer, who so wisely varies his Method, as particular Circumstances require, and as may most beneficially conduce to bring about the wise Ends of his Providence.

Nobody has hitherto been able to give any intelligible or satisfactory Account, concerning the Cause of this Principle of Fecundity in an Egg or a Seed *; we only know in general, that it results from the concurrent Act of two Animals, the one Male, the other Female. All Animals that are formed with Feet, Fins, or Wings, and have the free Power of transporting themselves from one Place to another, are divided into two Sexes under each Species, that they may confer their joint Offices in rearing their Young. On the other hand, those Animals which are confined all their Life to one Spot, are hermaphroditical, or have both Sexes conjoined in one Body, and procreate their Species without the Concurrence of a Mate. Of this Sort are Limpets, Sea-Ears, and several other Kinds of Shell-Fish; and such probably, on the Land, are the Bugs that live on Orange and Fig-Trees; as also those little Worms, which after having crawled some time over the Leaves of a sort of Oak, called the Holm-Oak, glue themselves thereto, and enshrine themselves within a little Cod, called *Kermes*, or Scarlet in Grain. If that general Law of Nature, which has divided Animals into two Sexes, be here charged with an Exception, yet it is such a one as is founded on the Inability of these Animals to go and seek out for Company, and on their particular way of living, for which the general Law of Nature has not provided. So that the Uniformity of the Law in general, and the Necessity of a particular Exception to that Law, do both equally prove the Unity of the Legislator.

So many thousand Species of Plants, formed on so many different Models, and yet all of them observing the

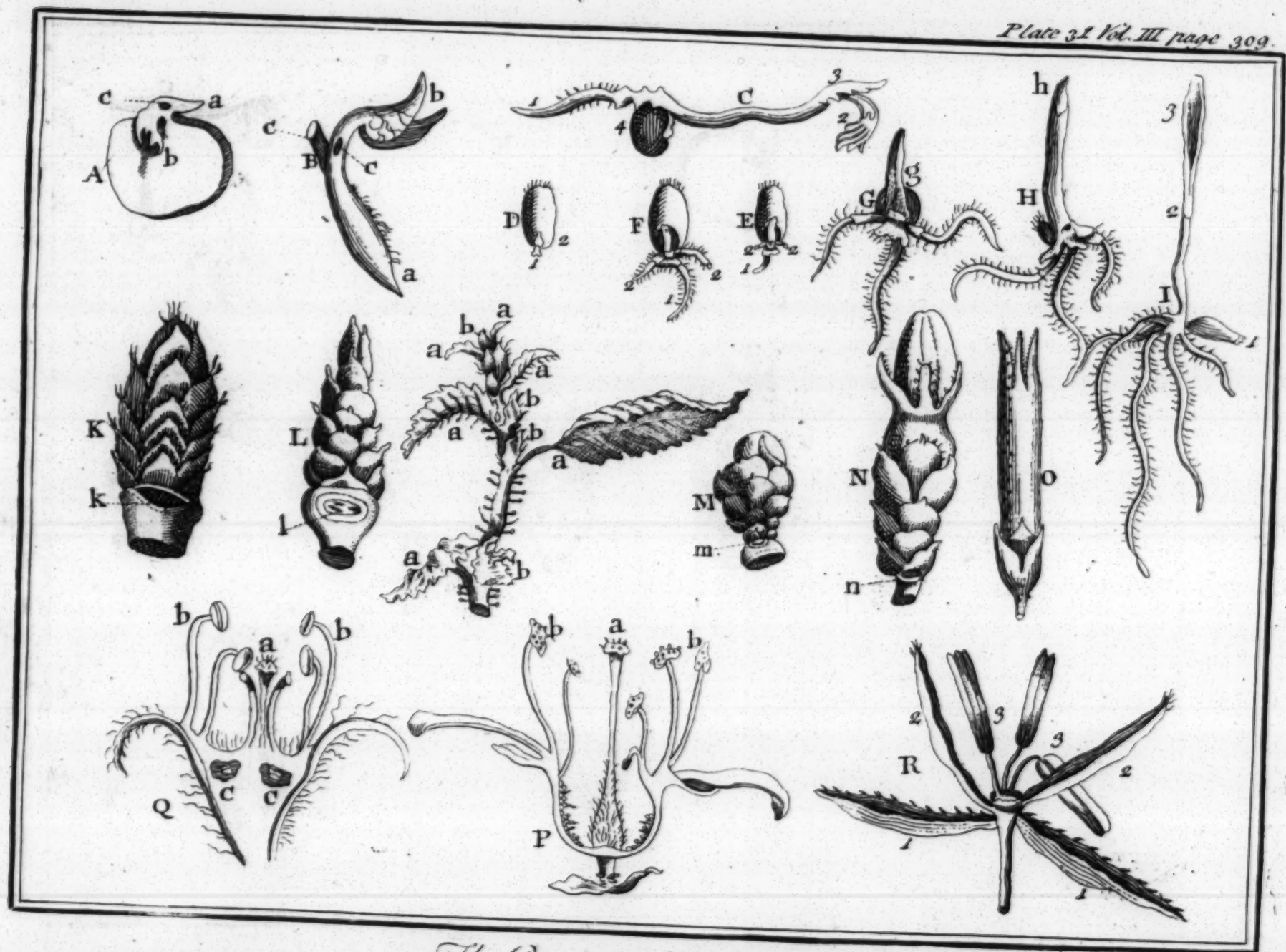
* See the Disputes of *Messrs. Læwenboeck, Andry, and Vallisnieri.*

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The Progress of Vegetation.

Toms sculp.

same Method of vegetating and perpetuating their Species, do in a wonderful manner prove the Unity of their Creator. There is not the Seed of any one Plant, which being put in the Ground, or such Liquors as are most agreeable to its Nature, that does not swell and unfold its Tunicles, to take in the first Nourishment for the little Gem which is placed near the Extremity of the Seed. That Point of the Plantule, which is situated nearest to the Surface of the Grain, and seems disposed to

Part I.
Dial. XIV.

make its Appearance first, is the Case which sheaths the Root: The Head of the Plantule is placed nearer the Centre of the Grain, into which it extends two Ducts or Canals, through which it imbibes its first Milk: When the Root begins to lengthen, the Juices which it receives incline it down towards the Earth, while the same Juices give the Head of the little Plant a quite contrary Direction, and raise it up above the Ground; where the Air, by injecting those volatile Salts and Juices, with which it is replete, in strait Lines into the perpendicular Tubes of the Plant, contributes to make it mount upward in an erect Posture.

When any Species of Plants deviates from this Rule, and is composed of slender or twisted Fibres, which, instead of ascending perpendicularly, cause it to creep along the Ground, Nature has made it amends for this want of Strength, by having provided it with a sort of Strings or Tendrils, with which, as with so many Hands, it clings and twines round the first Prop it finds; and by the Assistance of this Support, it is enabled to mount upwards like other Plants, and enjoy the Benefit of the open Air.

All terrestrial Plants derive their Nourishment from the Moisture which feeds them at their Roots, and that which they imbibe through their Leaves. Now whether there be any regular Circulation of the Sap, so as to cause it to ascend through the perpendicular Tubes of Plants, to perfect itself in the Leaves, and return through the Bark, or betwixt the Bark and the Wood, back again to the Root, as is very probable: Or whether Plants are sustained and grow by a Power of attracting their nutritive Juices, and are fed partly by the Moisture of the Earth,

Earth, which together with its vegetative Salts and Oils, ascends by Attraction up into the Leaves; and partly by the Moisture of the Air, which together with its Nitre, enters in at the Leaves, and distributes Nourishment through the whole Plant downwards to the Root, as divers Experiments seem to evince*: By which ever of these ways Vegetation is promoted, the whole Progress is uniform, and universally the same, and consequently denotes the Author to be but one.

The same careful Hand of Providence is no less visible in that Precaution which it has taken for the Preservation of all Plants whatever. The Head of the young Plant never makes its first Appearance above the Earth, but under a Covering, which serves to shelter it from the Injuries of the Air. There are several sorts of Plants, in which the two Lobes of the Seed extend themselves in the Form of two large Leaves, which, with officious Care, attend upon the young Stem, till it becomes sufficiently strong, to need its Protection no longer: There are some others, which instead of having two extended Lobes to guard them, raise their Heads under the Covering of a Sheath or Integument, which opens at the Top, or else are enveloped with Leaves, which fold one over another. The Buds, as well those that extend into Branches, as those which open into Flowers and Fruits, being the second Hope of the Plant, and so many Sources of new Plants, are clothed with the same Care: There are none of these which are not wrapped up, as it were, in swaddling Cloaths, or covered with a Sheath, which is for the most part composed of several Leaves, ranged one upon another, like so many Scales, that they may the more easily give way, and yield gradually, as the precious Gem which they contain, dilates itself, without exposing it to the Air by too precipitate an Opening. Many of these Scabbards are lined within with fine Threads or Filaments, or a sort of soft Down, which guards them against the Cold: Others again are secured by a Covering of Gum, against the Humidity of the Air. Let it be observed, that the greatest Part of these first Leaves or Scales wither and die away, when the Stem, the Branch, or the

* *Vegetable Statics*, by Dr. Hales.

Fruit, have no longer any Occasion for their Service. Thus does a little Grain of Seed, by procuring to us such inestimable Benefits in the Propagation of Plants, prove the Author of this, and all other Blessings, to be one and the same. We find, it is true, that some Plants bear their Stamina and Dust on one Stem, and the Pistils which contain the Seed on another; on the other hand, we meet with some that carry their Stamina, and the Capsulæ which hold the Seed, on the same Stalk, but in different Apartments; and lastly, that the greatest Number of Plants have their Stamina placed contiguous to their Pistils: But this Diversity is no Objection against the Unity of the Creator, and only proves that he has not confined himself to any one Method in the Productions of Nature, but has made choice of different means, all equally tending, notwithstanding their Variety, to the same beneficial End. In all Plants the Bed in which the Seed is contained projects from it a Calix or Cup, or Tunnel, and oftentimes, a Tuft or Plume, to admit and retain the *Farina*, or Dust, which falls from the *Apices* of the Stamina, when they open, or are expelled from them like Fume upon their bursting. The Learned are yet at a Loss to know what this Dust or *Farina* is, and how it comes to be the Principle of Fecundity in Plants. When seen through a Microscope, it appears like a Collection of fine Grains, which in different Plants are of a round, oval, or other Figure. Now, what shall we say is contained within those Grains? Are they the male Seed which passes through the fine Tubes of the Calix or Flower into the little *Capsulæ*, which contain the female Seed? Have these Calices, or Flower-Cups, Tubes of sufficient Diameters for these Grains to pass through into the *Uterus* of the Pistil, in order to impregnate the female Seed? Or does this Dust contain a subtle Spirit, or vital Juice, which confers Fecundity on the Plant? Let us modestly confess our Ignorance of this Matter, and acknowledge it to be a Mystery in Nature, which we have not hitherto been able to penetrate into, either by ocular Observation assisted with Glasses, or all the boasted Sagacity of Reason. Let us discard all uncertain Conjecture, and more vain Disputation on this Point, and content ourselves with knowing that the Success of
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the Seed depends intirely upon that of the Flower, both these having been formed in all Plants whatever to be mutually aiding and assisting to each other. Now forasmuch as the Discovery of this secret Operation in any one Plant, would enable us to account for the same in ten thousand others, we must necessarily conclude, that the Uniformity of those things we know, and the Uniformity of those things whose Operations we are ignorant of, do both equally prove the Whole to be all of a Piece, and to have been formed by the same Hand for the same End and Purpose.

Next to God's Unity, which of his Attributes, shall we say, appears most conspicuous in the Works of the Creation? His Power, his Wisdom, his Independance, or his Goodness? All these Perfections in him are equal, and the Prospect of Nature denotes them to be infinite like himself. His Attribute of Omnipotence will sufficiently evidence itself in one single Instance.

The Power of
God.

Let us lift up our Eyes to those heavenly Bodies, which do not shine with a borrowed Light, like the Moon and the Planets. The Sun and the Stars may be concealed from our View, but not deprived of their Light; the Moon may, by its Interposition, hide from us the Face of the Sun for a short time; and the superior Splendor of the Sun may eclipse, while in our Horizon, the Lustre of the Stars; but both the Sun and the

The Stars.

Stars have a native proper Light of their own, and which is inseparable from them, as from so many Globes of Fire. The Reason why they are seen by us, at such an immense Distance from our Earth, is because of their Magnitude, they being, probably, as big as the Sun, and consequently owe their Diminution to their Distance, and not to their Smallness. Let us therefore consider them as so many Suns, placed at a great Distance from us, that we might not be incommoded with their Heat, and yet enjoy the Benefit of their Light. This Proposition, which is undeniable true, being granted, it will infer one of these two things, either that these Suns were created solely for our Use, or that other intelligent Creatures do share the Benefit of them as well as we. If the Stars shine only for us, how magnificent

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to have so many bright Luminaries suspended in the arched Roof of Heaven, on purpose to beautify the Place of our Abode in the Night, without disturbing our Repose by too intense a Lustre. If, on the other hand, they are really so many Suns, which at the same time that they enrich our Prospect, illuminate a great many other Worlds; if that white Track in the Heavens, called the Milky-Way, be, as our Telescopes inform us, nothing else but a vast Collection of Stars or Suns still farther removed from us; what a Profusion of Worlds has the Hand of God scattered in that Part of the Universe, like Sand on the Sea-Shore!

The Milky-Way.

The Wisdom of God is inseparably linked together with his Power in all the Works of the Creation; these two Attributes of the Deity go always Hand in Hand, the Fury and Violence of the latter being always subject to the Guidance and Direction of the former.

The Wisdom of God.

The least Shock from those enormous Bodies, which continually move round us in such different Directions, would be sufficient to crush our Globe to Atoms; but notwithstanding the great Variety of Machines and Movements which constitute this complicated System, their Operations are regular and uniform; the Compasses of the Almighty have set them their Bounds, which they cannot pass, and infinite Wisdom so exactly regulated and proportioned their Weights and Velocities, that no unforeseen Accident, no foreign Power, can alter their Course.

The Weight of the superincumbent Atmosphere is every Moment ready to crush us to the Earth; but the Elasticity of the Air we inspire, does by a contrary Force so exactly counterbalance the Pressure of the external Air, that these two Actions mutually destroy each other without being perceived by us.

The Sea advances every Day toward us, as though it meant once more to drown the World; but no sooner is the Time appointed for its Reflux come, than it obeys the Summons and retreats, leaving us securely to enjoy the Benefit of its perpetual Flux and Reflux.

The Summer's Heat has its Bounds, and the Winter's Cold its Measure; the Action of one Muscle is tempered and balanced by that of another, in a Mite as well as in an Elephant; in a word, all Nature is compounded of Action and Re-action, Weight and Counterpoise, and of warring Powers continually tending to destroy each other, and yet all conspiring, under the Conduct of infinite Wisdom, with the utmost Order and Harmony, to bring about some general and useful Design.

The Independence of God.

Nor has the Supreme Being given us less Proof of his Independence, than of his Wisdom and Power in the Works of his Creation. As he is not subject to any other Being, so neither is he confined or streightened, either by his own Laws, or the Resistance of those Materials which he employs: He seems to have been delighted with the free Exercise of his Liberty, and to have pleased himself in that Variety which he has displayed both in the Fabrick and Decoration of the Universe.

When the Reflux of the Tide gives us an Opportunity of walking on the Sea-shore, we there find Shell-Fish of all sorts, and which probably are some of the Posterity of those which have been preserved many Ages in the Cabinets of the Curious. The Progenitors and the Offspring do perfectly resemble each other, and are all so many true Copies of one original Model; and yet what greater Argument can there be of Liberty, and the free Exercise of Power, than the Choice of so many different Models? All Shell-Fish do build their Houses with a glutinous Matter that perspires from their Bodies, and hardens into a Shell round them. Here we see different Architects using the very same Materials for the same Purpose; and yet we find among them as many Orders of Architecture, and Forms of Building, as there are different Species of Shell-Fish.

You find some Kinds of Shell-Fish and Sea-Insects which always adhere to one Place, and which seem to project a great Number of seeming Paws, which they move with great Agility. Here unadvised Men, who judge rashly and precipitately of Things, would be apt to think they had found a Flaw in Nature: What Occasion, say they, has an Animal for so many Paws, which never moves
from

from the same Place? But what they mistake for such, are really so many Trunks, or little Flails, with which this Animal stirs the Water, in order to give those oily Juices, and other Nourishment that floats upon it, a Motion towards itself. The greatest Part of Animals do indeed go in quest of their Food, but these have their Provision brought to them.

The same Liberty of acting does no less appear in the Formation of terrestrial Insects. Those to whom God has consigned the Verdure of the Earth for their Abode, do not indifferently fix their Quarters in any kind of Plants or Herbage; but each Species has its particular Dwelling, and inviolably observes those Laws which are prescribed it. The same free Will which has appointed them their respective Apartments, has also accommodated them with proper Instruments to build them. One has received a Wimble to bore a Hole in the Oak-Leaf, and to raise a little Tumour wherein to lodge itself and Family *: Another is provided with a hooked Knife, and two Saws, to hollow a Trench in the Bark of the Rose-Tree, and to dig two Ranges of little Cells wherein to deposit its Eggs †. Some of them are taught by Nature to fold themselves within a tender Leaf, and to hold it together in that Form, by means of several Threads or Filaments, lest the natural Spring of the Leaf should make it vary its Figure ‡. Some are so nice, that nothing but the Buds of Plants will serve their Turn; others are content to live on the Substance of the Leaf. Let it be observed, that those Insects which live in the Heart of Fruit, cannot live any where else; and therefore those People give into vain Apprehensions, who imagine that the Worm which breeds in Fruit can breed in the Stomach of a Child; or if these Insects could be hatched there, (which is contrary to the settled Course of Nature) and be able to bear the intense Heat of the Stomach, yet it would be impossible for them to multiply there, seeing they must first become Aurelia's, and then Inhabitants of the Air, before they can propagate their Species.

* See *Malpighi de Gallis.*

† *Vallisneri la Mosca de Rosai* 1713. *Tom. I. Edit. in Fol.*

‡ *Ibid.*

The same free, unconfined Power of the Supreme Being which has made choice of Plants for the Sustenance of so many Families, and oftentimes of the same Plant to be the Habitation of several Species of them, has not limited itself to the vegetable World in the Propagation of Insects. A little Meal or Chaff steeped in Water, and set in the open Air, will attract a Swarm of little Animals which traverse the Atmosphere to deposit their Eggs therein; they afterwards leave the Water to become Nymphs, and wing their way through a lighter Fluid. The greatest Part of these Inhabitants of Liquors are so small as to be imperceptible by us; and probably the Air swarms with these flying Insects, which are produced from them, and which serve for Food to others of a larger Size, and these again for Provision to the Birds: Thus do we perpetually receive Benefit as well from what we do not see, as from what we do. But the free spontaneous Exercise of the Divine Power does still more surprizingly display itself in that inconceivable Number of other Insects which subsist in Chalk, the empty Shells of Shell-Fish, decayed Wood, Stones, and even in solid Blocks of Marble: And as God never suffers the End of his Creation to be defeated through any Defect of Means, he has therefore (the better to facilitate their way into their respective Places of Abode) provided some with Fins, others with Drills, Files, and such other Implements as are most suitable to their kind of Life and Dwelling. He has assigned many of them their Lodging in the Bodies of Animals, some of which pass through the three different States of Worm, Nymph, and Fly; others of them always retain their vermicular State, and propagate in that Form. Of the former kind are those which lodge their young in the Skins of Animals, in their Nostrils, and other Parts, and which sometimes cause them to run mad*: Of the second Kind are those which live in the Stomachs and Intestines of Animals, and cannot subsist any where else, being placed there either to absorb the superfluous Juices which might otherwise increase too abundantly, or to keep in a State of Motion and Fluidity

* *Vallisneri dell' estro de buoi, &c.*

those Juices which by Stagnation or Congulation would become useless or noxious to the Animal *.

We see the same Liberty and Freedom manifested in the different Models of Birds and other Animals. What gradual Diminutions of Size do we find from the Ostrich down to the Humming Bird! What different Forms of Beaks from that of the *Toucan* down to that of the Fly-Bird †, which is still smaller than the Humming Bird! What different Gradations of Strength and Sagacity between the Elephant and the Ferret, the Buffalo and the Mouse! Hair is the general Covering of Quadrupeds; but the scaly Hide of the Rhinoceros proves to us, that God, if he had thought fit, might as well have given them any other Coat. Birds are, generally speaking, clothed with a feathered Garment; but the Hair of the Cassowary, and the Wing of the Bat, do plainly shew, that their Creator might have given them any other kind of Raiment, and have enabled them to fly without the Help of Plumage.

Thus does every thing appear to be the Effect of Choice and Liberty, no less than of Wisdom and Counsel; there is nothing in the Compass of the whole Creation produced either by blind Chance, or a fatal Necessity; nay, even those Bodies which act according to the most constant and stated Laws, are not necessarily determined in their Motions and Operations. It is no otherwise the Effect of absolute Necessity, that the Sun will rise again Tomorrow in our Horizon, than as that Body necessarily obeys the Command of the Almighty, who has set it its Course, and who can as easily change it to any other when he thinks fit.

But neither is this Liberty of the Supreme Being directed by Humour and Caprice. God does not exercise his free Power out of The Goodness of God. Ostentation, or merely to shew his Sovereignty, but always makes his Goodness the Rule of his Actions. And this important Truth

* *Vallisneri, de Verm. ordinari nel Corpo humano. See also De Vermicelli Spermat.*

† It is of this Bird, and not of the Humming Bird, that Pendants for the Ears are made, *Part I. Dial. XI.*

does visibly demonstrate itself in every Part of the Creation.

Even in those Things which are seemingly hurtful.

But where is the Goodness, it may be objected, in having created so many hurtful Insects, those destructive Worms, for Example, which insensibly eat and consume the Sides of our Ships, the Piles of our Dikes, and the Timber of our Houses?

These Worms, like all others, do by the Corruption of one Thing contribute to the Generation of another, and serve to promote that general Circulation of the Commodities and Productions of different Countries, on which Commerce necessarily depends. So mean an Animal, in Appearance, as the Pipe-Worm, does, by usefully employing the Vigilance of the *Dutch*, not only maintain, but bring Riches to the Inhabitants of *Sweden*, and to those who live on the Borders of the *White Sea*. Were they not under a perpetual Necessity of tarring and sometimes repairing their Vessels and Dikes at *Amsterdam*, in vain would the *Muscovite* and *Norwegian* barrel up the Pitch which distils from their Pines, in vain would the *Swedes* cut down the Oaks and lofty Fir-Trees that grow in their Forests. Thus does this little Animal, which we so much complain of as troublesome and injurious to us, become the very Cement which unites these distant Nations in one common Interest: And as some Insects are continually at Work at *Amsterdam*, for the Advantage of *Stockholm* and *Archangel*; so are there others in the *North* whose Labour is no less profitable to the *Hollanders*, inasmuch as they promote the Consumption of their Salt, Spices, and other Grocery-Wares, which are sent thither to season their Provisions, to preserve them from being corrupted by those Insects, and to cure their Fish, which they often use instead of Bread.

But let us not lose our Time and Labour in answering the Cavillings and Objections of those dissatisfied People, who are ever complaining and murmuring. To undertake a Defence of God's Conduct in the Government of the World is both unreasonable and unbecoming us, seeing his Providence does not stand in need of our Justifications: His Wisdom and Bounty are eminently conspicuous in all his Administrations, and the Difficulty we may

may sometimes meet with, in discovering the particular End of some of his Works, argues the Narrowness of our Understandings, not any Defect in his Goodness. The Prospect we have taken of Nature, does in every part sufficiently prove, that the Good of Man was the chief End proposed by Providence in the Works of the Creation, even in those very Things which seem hurtful or offensive; and that what we call an Evil, is oftentimes a real Good, and almost always designed to administer Occasion to the Exercise of some Virtue, which is more beneficial to us, than a State of Indolence and Inaction. Every thing is calculated by Divine Wisdom to make us richer, wiser, or better. This is a Truth which does not want so much to be proved as attended to, and is the Sum and Substance of true Philosophy. In vain does our shallow Reason attempt to fathom the Mysteries of Nature, and to pry into the Secrets of the Almighty, whose *Judgments are unsearchable, and his Ways past finding out*; nay, the Eye of a little Worm is a Subject capable of exhausting all our boasted Speculations, an Abyss wherein we lose ourselves; whereas the Contemplation of the Goodness and Condescension of God, so visibly displayed in the Wonders of the Creation, cannot fail of making us both wiser and better; and though his Goodness be infinite as well as his Wisdom and Power, yet we can in some measure keep Pace with this Attribute, by making Returns of boundless Love and Gratitude. And indeed, God seems to have laid the highest Claim to this Tribute of our Love, by the Care he has taken to manifest his Goodness in the most open manner, while at the same time he has concealed from us the most curious Particulars, with regard to the Structure and Essences of his Works; and to this our Ignorance of the Nature and Properties of Bodies it is owing, that we sometimes look upon one Thing as useless, and another as incompatible with Justice; whereas a thorough Sense and Persuasion of the Divine Goodness can alone satisfy all our Doubts, and resolve our Scruples. Some few Instances will illustrate my Meaning.

Among the various Kinds of single Flowers, whose Uses are so well known, we find a great Number of double ones, which are unproductive of Seed. Now to

In those Things which seem useless, as double Flowers.

what purpose, it may be asked, was all this Gaiety of Dress bestowed on a Flower which was created for no useful End? As it appears by easy Observation, that a double Flower is an Aggregate of single Flowers ranged regularly one within another on the same Stalk, some Botanists have thought they advanced a notable Discovery, by pronouncing them to be monstrous Productions; but how does this appear in a double Hyacinth? What is more beautiful than a full-headed Anemone? or more regular than a Rose with a hundred Leaves? Besides, the annual Return of these lovely Productions so constant in their proper Seasons, is so far from denoting them to be the Offspring of Irregularity or Chance, that it plainly proves them to be the Work of Order and Design; and what, shall we say, was this Design of their Formation, but to regale and feast our Sight? We might indeed imagine that the only End of Flowers was to foster and prepare the Seed of Plants; but we cannot deny that they are also designed at the same time to garnish our Habitations with the Elegance of their Structure, and the Brightness and Variety of their Colours, seeing we find great Numbers of those, which are exquisitely beautiful, regularly produced, which have nothing else to recommend them but their Comeliness. The divine Wisdom therefore may very aptly be compared to a tender fond Mother, who has not only provided for all the Necessities of her Children, but also condescends (though without stooping below her Dignity and Character) to humour them, and bear a Part in their little innocent Amusements.

The same Goodness and Condescension will help us to clear up another Difficulty, seemingly of greater Force, *viz.* how to reconcile the Creation of Animals for Slaughter with the Justice of God. The Necessity of killing them is agreed upon by all; for the Earth would cease to be habitable, were the Number of them not restrained: but then it may be asked, Is it agreeable to the Justice of God, to have created them to be butchered?

To find Fault with this Order of Providence, is to find Fault with the Hand that has enriched us; 'tis complaining that

that it has created Animals fit to cloathe and feed us, and, in short, that it has provided for our Wants. An Ox is not only delicious Meat, but it is a living Banquet that moves from Place to Place, is sustained by its own Labour, and surrenders itself to be a Feast for Man, when he has Occasion for it. Thus does it become doubly serviceable to us.

The many Animals which we see all round us, and which serve either for our Nourishment, our Cloathing, or Ornament, do only live and grow, that they may more effectually answer these Ends of their Creation. For this purpose has Nature provided them with Teeth to eat, and Stomachs to digest their Meat; with Arms to defend themselves; with Wings, Feet, Fins, &c. the better to preserve and subsist themselves in their respective ways of Life, till Man has Occasion for them.

But it may happen, that these Animals so nourishing and salutary, may increase and multiply in too great Abundance, that the Number of them may exceed our Wants, or be greater than the Fruits of the Earth can sustain, so that their dead Bodies, by lying unburied above Ground, may infect the Air, and cause a Contagion.

Objection.

All this was not only foreseen, but provided against; Nature having sufficiently stocked both the external and internal Parts of the Earth, and also the Waters, with Animals of Prey, and of the carnivorous kind, to prevent such-like Inconveniences, and which may properly be styled so many living Charnel-Houses, or animated Sepulchres, continually devouring whatever might be useless or hurtful to us. He who created these Animals with such voracious Appetites, did well foresee that their Services would sometimes exceed our Desires; but he also knew that they were only proportionable to our Wants; for Man stands as much in need of being punished, or forewarned, as of having his immediate Wants supplied; nay, it is more for his Good to be laborious, prudent, and vigilant, than to live in a State of Indolence and careless Security.

Answered from
the Being of
carnivorous Ani-
mals.

There always have been some murmuring and dissatisfied People, who, instead of praising and thanking God, as they

The Souls of
Beasts.

ought,

ought, for having made all Nature subservient to their Use, do turn the Prerogative and Dignity with which Man is honoured, into Matter of Complaint, calling his Right of Dominion over all other Animals, Usurpation and Tyranny; nay, not content with degrading themselves, they preach up for the natural Rights of Brute-Beasts, and proceed so far as to allow them the Privilege of Reason, which is only peculiar to Man.

We shall not have recourse to the Philosophy of *Des Cartes*, for Arguments to confute this unreasonable Supposition. To say that we have an absolute Right to dispose of all Kinds of Animals as our Occasions require, because they are mere Machines, is to found a certain Right on uncertain Principles. Man is conscious to himself, that he was born to inhabit the Earth, to cultivate it, and to enjoy the Benefit of its Productions; and the same natural Relation or Fitness of Things that informs him of the Lawfulness of eating the Fruits of the Earth, does also instruct him how to use the Skins and Flesh of Animals. It is not necessary for him to philosophize on the Nature of these Things, in order to make a right Use of them, any more than he is obliged to have a thorough Knowledge of the Body of the Sun, before he ventures to walk by the Light of it, of the Properties and Formation of Stones, before he uses them to build with, or of the Nature of Straw, before he lays it on his Land to manure it. The Essences of Things are concealed from us, but we are sufficiently acquainted with their Uses; and the great Care which the Sovereign Being has taken to proportion them to our Wants, and to keep up a constant Succession of them in our Favour, is a sufficient Indication that he has commissioned us to use them.

The Goodness of God displayed in the Instinct of Animals, and the Bounds of that Instinct.

When we attempt to explain the Nature of the Sun, or that of the Souls of Beasts, our Philosophy is quite at a Stand, and all our Reasonings and Reflections on those Subjects are either uncertain or unintelligible; but when we betake ourselves to contemplate on the Intentions and Goodness of God, in the Creation and Preservation of Animals, and in the different Uses to which he has adapted them, we easily attain to a sufficient Degree of Knowledge

Knowledge and Satisfaction in the Matter; viz. that the Soul in Beasts is a Principle of Life and Instinct, the Powers and Extent of which are regulated by the Occasion we have for them.

When the Work and Labour of the Day is over, and we find, ourselves disposed for Company and Relaxation, we find, upon our Return Home, a sociable sporting Animal to welcome and divert us with his innocent Tricks and Play, and which has moreover an inviolable and faithful Friendship for us, almost to a Degree of Reason. Do we want Houses, Cloathing, Food, or the Convenience of being carried from Place to Place! Behold! a Croud of other Animals offer us their Assistance and Labour; they know neither their Strength, nor the Hazard they run; to sustain Life, and to obey our Orders, is the Extent of their Knowledge. How many Drovers of large Oxen do every Day pass through the Cities of *London* and *Paris* to the Slaughter! How astonishing to see so many huge armed Creatures obedient to the Command of their Driver, though under the Conduct and Direction of a Child! Now to what can we ascribe such a tame and tractable Disposition in these Animals, but to the Will and good Pleasure of our kind Benefactor, who, as he made them for our Use, so has he put them under Subjection to us?

But notwithstanding, were all the different Species of Animals, which are in any degree serviceable to Man, to crowd together about him, and court his Neighbourhood like Sheep and Oxen, he would be incommoded with the Throng, while a great Part of the Earth became desolate and uninhabited: To the end, therefore, that all Nature might be stocked with living Creatures, and Man be disencumbered, Providence has so ordered it, that the other half of Animals should be formed with quite different Inclinations, and have something wild and savage in their Nature, disposing them to live alone in a kind of Independency; and accordingly, some are taught to wing the Regions of the Air, others to sculk in Woods and Dens, freeing Man, whom they shun, from their troublesome Company, and from the Pains of keeping them in Order and Subjection: But neither are they, so, beyond his Reach; for he knows their Haunts and lurk-

ing Holes, and neither their Swiftneſs nor their Strength can be their Security, when he is minded to make them Priſoners. Thus has the Goodneſs and Condeſcenſion of God provided for our better Accommodation, in allotting different Talents and Habitations to the ſeveral Claſſes of Animals; it is for us that they are ſagacious or ſtupid, nimble or aukward, tame or ſavage; and the Fierceneſs of ſome ought to excite our Gratitude and Admiration as much as the Gentleneſs of others.

The ſame Condeſcenſion which diſplays itſelf in varying the Inſtinct of Animals, has alſo greatly enhanced the Value of this Benefit, by conſining it within certain Bounds, beyond which it was never known to paſs. It is matter of Surprize, that thoſe Animals which have ſo much Sagacity and Cunning, underſtand one another ſo well, and ſhew ſo much Contrivance and Forecaſt in building their Houſes, and providing for themſelves and their Young, ſhould never improve by ſome new Diſcoveries, have no Notion of the natural Hiſtory of their Species, never concern themſelves in the Government of the World, or the Management of human Affairs, nor have any Curioſity or Senſe of Religion. Had they been endued with Reaſon, theſe would have been the neceſſary Conſequences of it: But their Faculties are proportioned to their Rank and Subordination in the Scale of created Beings, and to the Purpoſes for which they were deſigned. The Good of Man was the End of their Creation, and this End would have been defeated, had they been made reaſonable Creatures. The general Order and Courſe of Nature would be ſubverted upon ſuch a Suppoſition. The Raven would loath its Carrion, (by devouring which it frees us from that Stench and Infection it would otherwiſe breed in the Air) and prey on daintier Food; the Ox grown wiſer, would ſhake off the Yoke; the Horſe become more intelligent, would diſdain his Servitude; and the rational Dog, inſtead of being content with the Scraps and Refuſe he is now fed with, would feaſt himſelf with that Game which he is now taught to hunt down for us. In a word, the whole Animal Race would renounce their Obedience to Man, and, riſing up in open Rebellion, aſſert their Right of Liberty and Freedom. It is therefore the want of Reaſon that diſpoſes them for Subjection; and

it is for our Benefit and Advantage, that they just know enough to be serviceable to us, and no more.

Hitherto the Prospect of Nature has led me to the Knowledge of my Creator, and has demonstrated to me his Unity, his Omnipresence, his Wisdom, his Independence, and his Goodness. I can therein discover his peculiar Condescension and Friendship for me, in the Subordination of every thing to my Command and Convenience, and in that honourable Distinction which he has vouchsafed to shew in my Favour, between the narrow Limits of brutal Instinct, and the wide Extent of my Reason, which can soar up to Heaven, and even trace out the Author of my Existence.

But I find myself still embarrassed by a Difficulty more perplexing than any of the foregoing.

The Understanding and the Pleasures which God has dispensed to Man with so liberal a Hand, do affect me with the

The Desire of
Immortality.

highest Sense of Gratitude; but still the good things I enjoy, are attended with Dissatisfaction, and uneasy Longings: Notwithstanding all the Learning and Knowledge I find myself capable of attaining to, yet my Desires aim at something farther, and my Wishes transport me beyond the Bounds of my Reason. Had I the whole Earth in my Possession, and were sole Master of every thing this World can afford, yet I find myself capable of relishing still higher Enjoyments; at least my Happiness would be defective in the main Point, Duration and Stability. He that fills my Soul with Joy at the Return of the Morning, who raises so much Delight and Satisfaction in my Mind, upon the Discovery of a new Truth, and regales my Senses with so exquisite a Relish, upon tasting any delicious Fruit, could doubtless have augmented my Felicity, and made it eternal. I am inwardly persuaded, that God can do this; I dare desire it; nay, confidently hope that he will do it. All Men die, it is true; but all have the same Desires and Hopes that I have; nor was it ever in the Power of Death to deprive Mankind of this earnest Longing, this ardent Expectation of a happy Hereafter. We cannot suppose that God, who has displayed so much Order and Regularity in our Bodies, has been less mindful of our Souls; for his Wisdom and Goodness

ness are infinite : and consequently cannot take a Pleasure in deluding such weak, helpless Creatures as we are, with false Hopes, in planting in us an invincible Desire of Immortality, which he has not designed to gratify. No, God had done nothing in vain, and therefore will not defeat the Ends of his own Providence.

God has given Activity to the Feet, and accordingly, we make use of their Office to transport us from one Place to another ; he has bestowed Articulations and Flexibility on the Fingers, the better to lay hold on, and fashion those things we stand in need of, and has given us frequent Occasions of making them thus useful to us : He has created in us Hunger and Thirst, and at the same time amply provided us wherewith to gratify these two Appetites ; and, in a word, established the most exact Agreement and Fitness betwixt every Faculty and its Object. Let us not then say, that God has in vain implanted in the Hearts of all Men, of all Ages and Countries in the World, a constant and inextinguishable Desire of being more enlightened and more happy : This Thirst after Knowledge was not given him for no End, this Hunger after Happiness will one Day be satisfied. This pleasing Consideration distends my Heart with Joy, and the Survey of the Universe, which has already discovered to me the fundamental Principles of Natural Religion, leads me on farther to inquire into those Means which may secure to me this future Felicity.

And here we might take Occasion to join the Consideration of God's Justice and Providence to what we have already remarked on his other Attributes ; but, in order to do this, we should be obliged to pass on from the View of Nature, to that of Society and Grace : Let us not therefore quit the first Subject, without observing thereupon, whatever has an immediate relation to Revelation. Nature itself is our first Revelation, and therefore we ought not to pass over any thing it may present us with, either by way of Preparative to, or Proof of the second.

The *Hebrews* did preserve, and transmit down to us, the History of the Origin of the World, with the Promises of the *Messiah*, and of a Life to come. The three most remarkable Transactions that this Tradition teaches

The Agreement
betwixt Nature
and Revelation.

teaches us, are the Creation of every thing by the special Will of God, the universal Deluge, and the final Conflagration of the Earth. Infidelity has endeavoured to sap the Foundation of Revelation, by leveling all the Artillery of vain Systems of Philosophy against these three Truths: But the View of Nature which we have taken, does, by shewing the Falsity of these Systems, and by grounding itself on Revelation, intirely destroy all the Pretences of Infidels.

It is a Conjecture which has met with some Advocates, that the Planets might formerly have been so many Suns; but that these Suns, being incrustated over and obscured by some Layers of grosser Matter settling upon them, from luminous became opaque Bodies; that is to say, in their Phrase, habitable Earths. Some Spots that have been discovered in the Sun, and some Stars that have disappeared, for Reasons beyond our Comprehension, have added some Weight to this Conjecture: By degrees, it came to be laid down as a fixed Principle; and (as if this Conversion of Suns into Planets, had been proved by undeniable Arguments) now passes for matter of Fact with some Men of Learning. The Earth, according to them, is nothing but an Aggregate of dense Bodies formed into a Crust, by Length of Time, round a Globe of Fire, which occupies the Centre of it. It is very plain, that such a System of Philosophy is no ways consistent with Revelation; but it is also plain, that it is no less repugnant to the settled Course of Nature, and right Reason, than it is to the *Mosaical* Account.

There is a wide Difference between the Creation of the different Parts of the Universe and their Conservation: They may be kept in their constant Course and Order by certain general Laws, which God has established, and which he supports with equal Liberty and Dignity; but they neither could be created nor formed by any Operations of the simple Laws of Motion. There is neither Beauty, Order, nor Goodness in any thing, but what was produced by the special Will of the supreme, all-wise Being; and it is as impossible for a Sun, by any Incrustation, to become an habitable Earth, or for an opaque Body, by any Removal of the Crust, to become a Sun, as it is for any Combination of Motions to convert a
Stone

Stone into a Man, or a Man into a Tree. Such Transformations as these, would be scarce pardonable in *Ovid's Metamorphoses*.

But let us for once allow these new Modellers, who are for excluding God out of the Creation, or at least for producing all things from Motion impressed upon Matter at the Beginning; let us, I say, allow them to make the Earth after their own way; we will grant them a sufficient Stock of Matter to work upon, a circular Motion, and as much Time as they can desire for the Execution of their Scheme; let them chuse their Laws of Matter and Motion, either from *Des Cartes* or *Newton*; in short, suppose the Earth made according to their Fancy: but then this Earth is naked and desolate, without Verdure, and without Inhabitants; nor will they be able, with all their Mechanicks, to make it any other than a wild barren Defart. Suppose but the least Blade of Grass to grow in it, or the meanest Reptile to creep upon it, you infer a Necessity of an intelligent Being, and a particular Act of his Will in the Formation and Organization of this Vegetable or Animal. Now, if mere Motion cannot form the Rings and Bowels of a Worm, or the Vessels of a Plant, shall we suppose it capable of forming a regular, habitable Earth? Can it proportion the different Strata of it to the Occasions of its Inhabitants, allot it its just and proper Measure of Air, Water, and Fire, and fix its Orbit at such an exact Distance from the Sun, that it shall neither be frozen by excessive Cold, nor burnt up by too vehement a Heat? If then our Earth was stocked with Plants and Inhabitants by the particular Appointment of the Divine Being, can there be any room to doubt, whether the same omniscient Author who created these, did by a like express Act of his Will assign them their proper Habitations in such Elements and Soils as are most agreeable to their Natures? Had this Earth been formed according to the Fancy of these Philosophers, it would indeed have consisted of an Assemblage of several Strata of Matter, ranged one upon another round a common Centre, according to their different specific Gravities; that is to say, the more dense would be nearest to the Centre, and the lighter farthest from it: but still this Earth would be useless for want of a just Disposition

Disposition of its Parts ; it would have no Atmosphere, and consequently be deprived of the Benefit of the Air's Gravity and Elasticity ; no Diversity of Soil in the external Layer or Surface of the Crust, to accommodate the different Grains and Seeds of Plants with a Bed and Nourishment, proper to their respective Natures and Qualities ; no spacious hollow Vase, to contain the vast Stores of those Salt-Waters, which are so necessary to Vegetation, and the Fertility of the Earth ; no Mountains to condense and collect the Vapours exhaled from the Sea, and to precipitate the Rivers on to the Plains ; no regular Strata of Sand prepared, to serve by way of Reservoirs of that Water which is to feed the Fountains ; no Layers of Clay to be a Basis to the Springs and Wells ; no subterraneous Waters to distribute through the Bowels of the Earth the Salt, Bitumen, Sand, Loam, Vitriol, Mercury, and the Sulphurs, in order to form, by their different Dispersions, Concretions, Fermentations, &c. Mineral Waters, hot Baths, precious Stones, Stones for Building, Metals, &c. up and down in different Parts of the Earth. Is it possible to believe, that all this curious Mechanism, all these Operations, so far surpassing our Comprehension, could be produced by fortuitous Incrustations on a Globe of Fire ? Could all the Philosophy in the World have contrived such an useful Fabrick ? In no wise : We must allow then, that all this wonderful Apparatus, this amazing Organization and Fitness that appears in all the Parts of our Globe, was the Work of immediate Creation, the Act of wise Counsel and Design. Thus far our View of Nature does perfectly comport with the Account of *Moses*.

It is an allowed Truth, say they on the other hand, that nothing but unpardonable Infidelity, and wilful Blindness, can affirm that that Correspondence and Harmony, that Symmetry and Proportion, which is every where visible in this beautiful terrestrial Machine, could be produced by any general Laws of Motion ; and that the Mind is much better satisfied with thinking that the Light, the Sea, the Verdure of the Earth, and all the other Parts of Nature, received their Form and Station by the express Order of the Almighty : But then, say they, is it not very surprizing and unaccountable, to read in the

Book

Book of *Moses*, that the Light was created before the Sun, and that the Waters were divided into two Parts, one of which possesses the Earth, the other the Firmament, a Place that we have not any Knowledge of ?

Some Interpreters are of Opinion, that the *Mosaical* History of the Creation was adapted to the then present State and Condition of the *Hebrews*, and calculated to serve, by way of Precaution, to guard them against the Idolatry of the *Canaanites* and *Syrians* on the one hand, who worshipped *Moloch*, or the Sun, as the Author of Light; and of the *Egyptians* on the other, who paid their Adorations to *Isis*, as the Goddess and Dispenser of wholesome and refreshing Rains, of the Overflowings of the *Nile*, and of the Fruitfulness of the Earth.

It is true, the Account of *Moses* does strike at the Root of this double Idolatry, by shewing that God alone is the Author of all that Beauty which appears in the Creation, and the sole Giver of every good thing: But he has not had recourse to a Lye, to establish this important Truth, nor advanced any thing in his History, which is repugnant to true Philosophy.

Light pre-existent to luminous Bodies.

To begin with Light. Now Light is visibly pre-existent to luminous Bodies: This may seem a Paradox at first Sight, but it is not therefore a less evident Truth: By Light we do not mean that Sensation, which

we experience in ourselves on the Presence of any illuminated Body, but that inconceivably subtle Matter, which makes an Impression on the Organs of Sight, and paints on the optick Nerve those Objects, from the Surfaces of which it was reflected to us. Light then, taken in this Sense, is a Body quite different from the Sun, and independent on it, and might have existed before it, seeing it does now exist in its Absence, as well as when present. It is diffused from one End of the Creation to the other, traverses the whole Universe, forms a Communication between the most remote Spheres, penetrates into the inmost Recesses of the Earth, and only waits to be put in a proper Motion to make itself visible. Light is to the Eye, what the Air is to the Ear: Air may not improperly be called the Body of Sound, and it does equally exist all round us, though there be no sonorous Body to put it in Motion; so likewise the Light does
equally

equally extend at all times from the most distant fixed Stars to us, though it then only strikes our Eyes, when impelled by the Sun, or some other Mass of Fire. The Difference betwixt the Propagation of Sound and Light consists in this, that the Air, which is the Vehicle of Sound, being, beyond all Comparison, more dense than the Vehicle of Light, its Motion is much slower: Hence we may account for that common Phænomenon, why we do not hear the Sound of the first Stroke of a Hammer, when at a Distance from it, till it is at the point of giving the following Blow; whereas Light is propagated with incredible Swiftneſs, though at some small Distance of Time between its receiving its Impulse, and its communicating it to us; seven Minutes, according to Sir *Isaac Newton's* Calculation, being sufficient for its Passage from the fixed Stars down to us. This Difference of Velocity, between the progressive Motion of Light and that of Sound, is sensibly demonstrated, by firing a Gun in a large open Plain, where the Spectator, at a great Distance from it, will perceive the Flash a considerable Time before he hears the Noise.

The Body of Light, therefore, does either exist independently of the luminous Body, and only waits to receive a direct Impulse from it, in order to act upon the Organ of Vision; or we must suppose, that every luminous Body, whether it be the Sun, a Candle, or a Spark, does produce this Light from itself, and project it to a great Distance from its own Body: There is no Medium between these two Suppositions; and either the one or the other must be true: But to assert the latter, is to assert a very great Improbability; for if a Spark, which is seen in every Part of a large Room, fifty cubick Feet in Dimensions, emits from its own Substance a Quantity of Light sufficient to fill the whole Room, then there must issue from that Spark, which is but a Point, a Body, the Contents of which are fifty cubick Feet: How incredible the Supposition! suppose the Lanthorn on the Light-house of *Messina* to be seen only eight cubick Leagues, of which itself is the Centre; it will follow, that an Eye placed in any Point of those six cubick Leagues will discern it, and consequently so much Space will be filled with the Light of it. Now how incredible, that a little Fire, some few Inches in Diameter, should diffuse around it a Substance capable of filling eight cubick

cubick Leagues! Suppose the Lanthorn concealed, and the Light immediately disappears; let it be uncovered the Moment after, and it will instantly be seen as far as before, and consequently fill eight cubick Leagues of Space with fresh Light; then how many times eight cubick Leagues of luminous Matter, will all the successive Instants of Illumination produce in one Night's time! Sure nothing was ever more inconceivable. On the contrary, how simple and natural is it to suppose, that as the Air existed before the Bell that put it in Motion, and caused it to vibrate into Sound; so, in like manner, the Light existed round the Fire of *Messina*, before the Lanthorn was illuminated, and only waited to be put in Motion by the Fire, in order to make an Impression on the Eyes of the Mariners! The Sun and Stars do by the same means make themselves visible, without suffering any Diminution of their Substance, by continual Emanations of luminous Matter, into those vast Regions of Space through which we behold them, God having placed between those luminous Globes and us, the Body of that Light which we see, and which is impressed on the Organs of Vision, by their Action and Influence; but does not proceed from them, nor owes its Existence to them. The Account of *Moses*, therefore, as to this Particular, is agreeable to Truth, as well as an useful Lesson of Caution, when he informs us, that God, and not the Sun, was the Author and Parent of Light, and that it was created by his Almighty *Fiat*, before there was a Sun to dart it on one Part of the Earth, and a Moon to reflect it on the other.

As to what *Moses* relates concerning the Waters beneath the Firmament, and the Waters above the Firmament, we find it confirmed by daily Experience. All Water that is exposed to the open Air, will suffer some Diminution in its Quantity by Evaporation, a hot Sun being sufficient to exhale above an Inch in one Day; from whence we may form a Judgment of the Quantity of Water, which is raised in Vapours every Day, from the immense Surface of the Sea. The greatest Evaporation always happens in the hottest Days of Summer, though it be at that time least perceivable. These Waters ascend into the higher Regions of the Atmosphere, to join those which were there before. Here then are Treasures of Water really
existing

existing over our Heads, though so rarefied, as not to be visible to us ; and as the Air does sustain them at a much greater Height, than the Flight of the most soaring Birds, they may very properly be called the Waters of Heaven, or the Waters above the Firmament.

Moses, in his History, first describes the Earth as intirely covered and concealed under the deep Abyss of Waters ; and afterwards making its Appearance above them, by the inferior Waters being distributed into those Beds and Cavities, which were prepared for their Reception ; and by the Elevation of the others, which ascended up in Vapours, and were dispersed through the exalted Regions of the Air, immediately upon the Creation of the Fire or Light. The exact Quantity and Height of these rarefied Waters is only known to Omniscience ; but the Existence of them is proved beyond all Contradiction. Thus does the concurrent Testimony, both of Nature and of the sacred Records, bear witness to this Truth, and point out to us another Ocean of Waters suspended over our Heads, and fluctuating continually in the wide Extent of Heaven, to serve in the Hand of the Almighty, as an Instrument of Fruitfulness or Devastation, of Liberality or Correction.

Now, as the Waters that are above us, did ascend thither by Rarefaction, so might they descend by Condensation ; and uniting their Stores again with those upon the Earth, once more cover it with an universal Deluge, without a new Creation of Waters. Thus will the natural Possibility of an universal Deluge appear from the sufficient Abundance, as well as from the Existence, of the superior and inferior Waters.

The Physical
Possibility of the
Deluge.

Some learned Men have undertaken to measure the Depth of the Sea, in order to inform themselves, whether or no there be a sufficient Quantity of Water in Nature, to cover the Earth above the highest Mountains ; and taking their Philosophy for the Rule of their Faith, have dared peremptorily to pronounce, that God has not done what they cannot conceive how he could do. A Man may take the Dimensions of his Land, or gauge a Pipe of Wine or Oil ; but can he take the exact Height of the Atmosphere ? Or can he with Line and Plumbet fathom
the

the Depth of the great Abyfs? How vain then must be the Attempt to measure the Sea, when we know neither the Extent nor Depth of it! How presumptuous to draw any Arguments against the History of the Deluge, from a supposed Insufficiency of Water for that Purpose, when, for what we know, there may be a more copious Magazine of Water in the Air above us, than upon the Earth! In a word, what Obstinacy and wilful Blindness, to oppose the Possibility of a Deluge, with any shallow Arguments or Suggestions of our own weak Reason, against a Croud of Monuments, which do undeniably prove it to be Matter of Fact!

All Parts of the Earth * do bear Witness to the Truth of this Doctrine, whether we seek for Informations in the great Continents, or in the smallest Islands, on the Tops of Mountains, or in the Bowels of the Earth; forasmuch as in all these Places, we find intire Beds of Shells, sometimes of different Sorts, sometimes of the same; as also the Teeth of Sea-Fishes, whole Fishes petrified, and the Spawn of Fishes; Sea-Plants, either petrified or impressed on Stones; and, in short, all the Spoils of the Sea: Now, how shall we account for such a general Dispersion of marine Bodies all over the Globe, but from some one universal Catastrophe!

Some learned Men have had recourse, for the Solution of these Phænomena, to Alluvions, Volcano's, or some accidental Causes, which are not mentioned in History; but those Naturalists which deserve the most Credit, such as Masons, those that work in the Mines, and the most authentick Travellers, have always been of Opinion, that these marine Bodies, which are every where scattered and buried up and down in the Earth, could not be lodged there, but by that general Confusion and Mixture of Substances caused by the universal Deluge. Thus, while Men of great Parts

* See the Accounts of Travellers, particularly *Misson's Travels*; the *Memoires de l'Academie des Sciences*, almost for every Year; the *Abridgment of the Philosophical Transactions*, Vol. II. Chap. on *Minerology*; the Collection of the Chevalier *Vallisneri*, intituled, *De Corpori Marini ubi su Monti si trovano*; the *Theory of the Earth*, by Dr. *Thomas Burnet*; *Woodward's Essay towards a Natural History of the Earth*: And to these may be very well added, the Testimonies of *Herodotus*, *Plutarch*, *Solinus*, and *Pomponius Mela*, on the Remains of the Deluge.

and Learning, rather than think in the common way, have recourse to local Accidents, and wild unsatisfying Schemes of Philosophy, People of plain Sense, and moderate Discernment, can receive full Satisfaction on this Head, from that Account of the Flood by *Moses*, which has been faithfully transmitted down to us. These petrified Bodies then, so seemingly useless, do speak Demonstration to our Senses, and are a Language which is understood by the most common Capacities, having been appointed by Providence as so many standing Monuments of the most remarkable of all Transactions, and are, with regard to the History of *Moses*, the same as Medals to the *Roman* History.

Here, my dear Chevalier, you may probably desire to know how I conceive the Water of the Sea could carry those Shells, which do not swim, but remain at the Bottom, on to the Steep of Mountains; and how it came to pass, that those marine Animals, which formerly inhabited the great Deep, are now found buried under several Layers of Earth, at a considerable Distance beneath the Surface of it. Provided then we keep close to the History of the Deluge, and consider it as an Event, the Universality of which is attested by the Scriptures, the Histories of all Nations, and by the most exact Inspections into Nature, we may be allowed to venture at a Conjecture touching the Manner how this Effect might be produced. A Conjecture, it is true, is not exempt from Objections, and may happen to be false; but the Falsity of a Conjecture, concerning any Point of History, does not destroy the Credibility of such Transaction, seeing God might bring about an Event by ways and means, which surpass our Conceptions. Be pleased therefore to look upon what I am going to offer on this head, as an Hypothesis of no great Importance to the Subject itself, whether true or false; and which may at least serve to introduce you to a nearer Acquaintance with the Constitution of our Globe, and its annual and diurnal Revolutions in the solar System.

The chief of what we learn from the Scripture, relating to the Deluge, may be reduced to these Heads; that the Cataracts or Reservoirs of the Heaven were opened, and that the Treasures of the great Abyss were broken up; that the Water increased

A Conjecture concerning the Change caused in the Earth by the Deluge.

to the Height of fifty Cubits above the highest Mountains ; that after the Deluge the Rainbow was appointed by God as a Token, that he would not destroy the World again by Water ; and that the Life of Man became much shorter after than it was before the Flood.

The general Tradition of Nations has preserved and handed down to us the Memory of the Deluge, and of a few Persons that were saved in a Boat in order to restore Mankind. The same Tradition, as perpetuated in the Writings of the ancient Poets, does also inform us, that the Earth did formerly enjoy one continual Spring ; but that Mankind, abusing the Blessings of Nature, and degenerating into evil Courses, were swept away by one universal Inundation ; and that the Earth was repopled by a Generation of Men much shorter lived, and subject to a perpetual Vicissitude of Seasons. All Nations have in like manner agreed, that the Bodies of Men have, both in Stature and Constitution, suffered a great Diminution and Decay *. This Persuasion was originally founded on the Revolution caused by the Deluge, and has prevailed down to the present Time, though the Life of Man, as also his Stature, and the Temperament of his Body, have now been at a Stand, and continued nearly the same for many Ages.

The Testimony of the sacred Records, and the universal Tradition of Nations concerning this Matter, are abundantly confirmed by what Nature discovers to us in those Footsteps of the Deluge, which still remain in most Parts of the terraqueous Globe, and do plainly teach us, that nothing but an universal Dislocation, or Dissolution of the Parts of the Earth, could occasion that Mixture and Confusion of Substances which we find in several Places, as of terrestrial Plants, the Bones of Animals, Masses of broken Metals, and sundry Works of human Art, together with the Shells and Teeth of Fishes, and other Productions of the Sea. Give me Leave then to offer a probable Conjecture by way of solving these Phænomena.

Although the Earth did before the Deluge, as well as now, consist of several Strata of Matter lying one upon

* See the *Iliad* of Homer, the *Æneid*, and more particularly the *Georgicks* of Virgil, towards the End of the first Book ; *Scilicet* & *Tempus veniet, cum, &c.*

another, of Mountains, Valleys, Plains, great Collections of Water or Seas, and all other Parts essentially necessary to the Constitution of an habitable Globe; yet, notwithstanding, its Form then was probably different from what it is at present, and its Atmosphere or Firmament not exactly the same as now: And this cannot be denied, seeing God, who wrought a Change in the Life of Man, might as easily effect the same in the Structure or Form of his Dwelling. And St. Peter seems plainly to authorize such a Supposition, where he says, that the antient World perished by Water, the Heavens and the Earth which now are, being reserved unto the Fire of the last Day*.

Let us suppose now, that the former Earth described its annual Orbit, or Ellipsis, round the Sun, having its Axis perpendicular to the Plane of its Orbit, that is, without having a greater Inclination to one Part of it than another.

Let us suppose also, that as this Earth was designed to be the Habitation of a very long-liv'd Race of Men, who were to multiply exceedingly, the Surface of the Land was much greater than that of the Sea, which, the better to accommodate Mankind with Room, was partly open and partly concealed under the Earth; so that there were on all Sides large Magazines of Water, or different Seas, which held a Communication with each other under Ground, by means of one common Receptacle or Rendezvous of Water: And the Scripture seems to countenance such a Disposition or Distribution of the Waters, by calling this vast Bed, or Store-house, of them by the Name of the *Profound Abyss*, and the different Gatherings of the Waters by the Name of *Seas*, as being many. From these two Suppositions, which are neither repugnant to Scripture nor Philosophy, do naturally flow all those Particulars which we find in Scripture, in the Traditions of the Antients, and in the present State of the World.

Abyssus profunda.

Congregationes

Aquarum.

Haijamim.

Maria.

Theom. Rabhah.

* Ο τότε κόσμος ὕδατι κατακλυσθεὶς ἀπόλατο, οἱ δὲ νῦν ἔσαντες καὶ ἡ γῆ ——— τυπὴ τηρέμενοι, &c. Epist. 2. chap. 3. ver. 6, 7.

Now the Axis * of the Earth not being inclined to the Plane of the Ecliptic, the Plane of the Earth's Equator did coincide with the Plane of its annual Orbit, and consequently intersect the Body of the Sun, or, in other Words, the Earth's Equator was always opposite to the Sun. From such a Situation is necessarily follows, that all the Climates of the Earth, except in the middle of the Torrid Zone, did enjoy a constant and pleasant Temperature of Weather; Day and Night were equally divided to all Places alike, consisting each of 12 Hours; the Air was always pure and serene; and there was a perpetual Spring all over the Globe; the Sun and Moon did regulate the Course of the Year, not by the Diversity of Seasons, but by the Change of Places, the Earth in its annual Revolution in its Orbit round the Sun, passing under the twelve Constellations of the Zodiack, so that when it was under *Libra*, the Sun appeared to be under *Aries*; and when the Earth passed under the Sign *Scorpio*, the Sun seemed to be in *Taurus*: The Revolution which the Sun seemed to perform in one Year, the Moon did really perform every Month, renewing its Phases then periodically, as it does now. Thus did these two Lights which presided, one over the Day, the other over the Night, serve as two Regulators to Mankind, whereby to fix the Length of the Year, and to measure the several Portions of Time.

Had Man continued in his first State of Innocence, he might, without the Pains of Cultivation, have gathered the successive Fruits of the Earth, which God had blessed and enriched with spontaneous Crops, and made, for his sake, one continued Garden of Delights; whereas the Guilt contracted by the Fall, and his sinful Disobedience, brought upon him the Weight of that Curse which was denounced against the Earth for his Punishment; for from that time it brought forth Thorns and Thistles, and

* The Axis of a Globe is a Line passing through the Centre of it, from one Point of its Superficies to the opposite Point, like a Needle run directly through an Orange. Now the Earth, by turning round upon this Line, or Axis, does successively cause every Point of its Body to turn towards and from the Sun: but as we do not perceive that Motion of the Earth, which is the Cause of our approaching nearer and nearer to the Sun till Noon, and then of our departing farther and farther from it till Midnight, we are apt to think the Motion to be in the Sun and the Heavens, and not in our Earth.

by the Sweat of his Brow was he obliged to earn his Bread. But as the Menace of Death which was then denounced against *Adam*, was not executed till a long time after, so neither was the Curse which God pronounced against the Earth, fully accomplished till after the Deluge : Hitherto the Earth retained the Vigour and Beauties of Youth ; it not being then, as since, deformed and furrowed with Caverns and Fissures ; there were then no Inlets for the Air to penetrate into the Bowels of it, no subterraneous Fires to kindle it into Violence and Fury, causing Earthquakes and dreadful Convulsions ; the Atmosphere enjoyed a State of Calmness and Serenity ; the gentle Zephyrs at the Approach of Day dispersed the Morning fragrant Dew over the Face of the whole Earth, and the Vapours, which were exhaled from the Sea in the Day-time, condensed and descended in the Night in refreshing Moisture, for the Nourishment of Plants and Vegetables, and to feed the Reservoirs of Fountains and Rivers with new Supplies ; the Air was not put into violent Agitations by blustering Winds ; there was no Storm or Tempest, Hail or Thunder ; for though all these Meteors have their respective Uses agreeable to the present Order, and settled Course of Nature, yet the antediluvian Earth, as it did not stand in any Need of them, so neither was it incommoded by them.

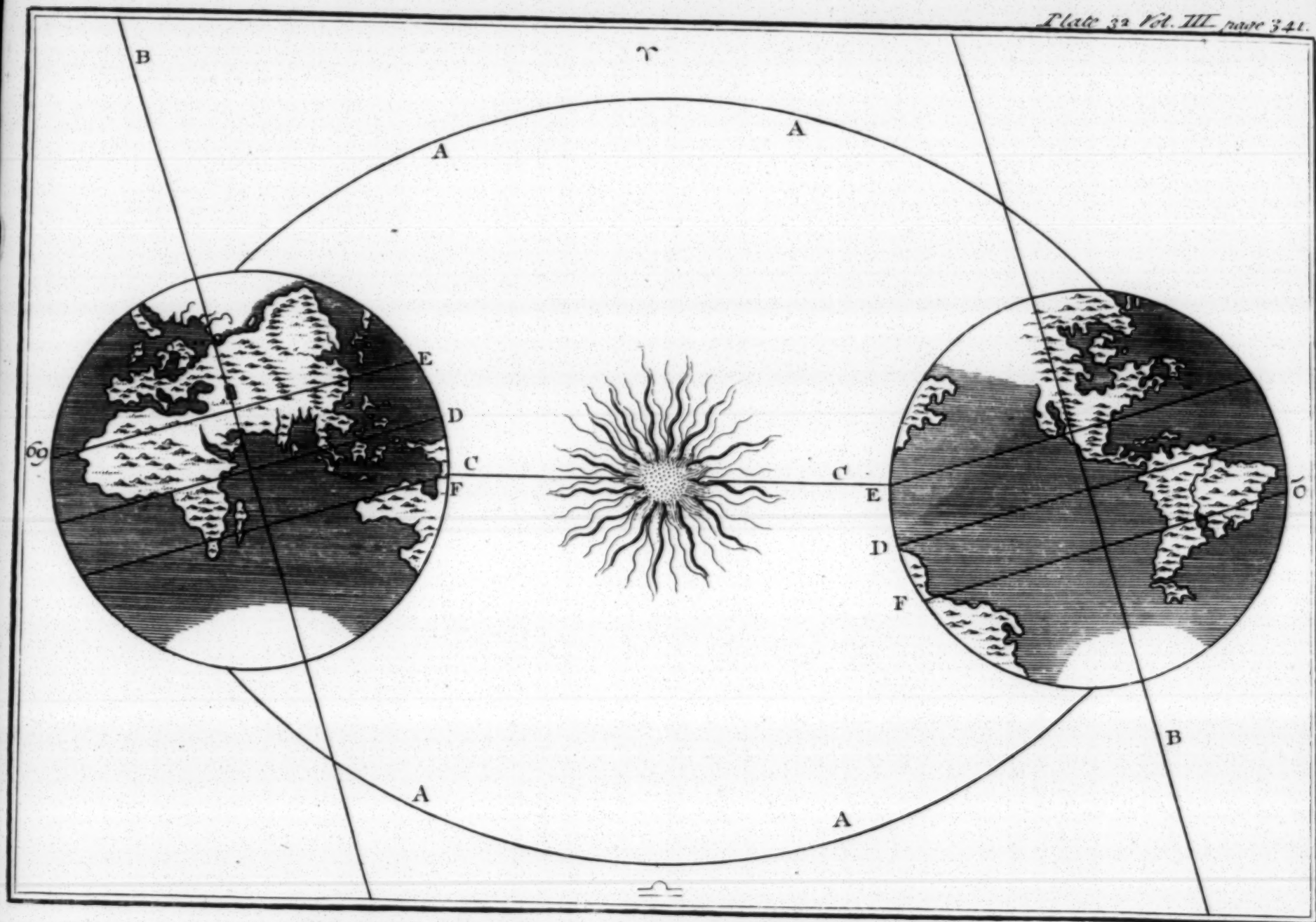
By a natural Consequence of this uniform Temperature, which presided every where and at all times, the Trees did perpetually retain their Verdure, and brought forth Fruit, blossomed and budded at the same time ; the present Crop was but an Earnest of that which was to succeed, and uninterrupted Plenty exalted her full Horn in every Place.

The Clemency and Temperature of the Air could not fail of having a beneficial Influence on the Bodies of Men, and causing Longevity. In a word, there was no Blemish in Nature, nothing to defile the Earth but the Wickedness of its Inhabitants, who were taken up, in the midst of this Plenty, with nothing so much as the Gratification of their Pleasures and Passions, converting those Blessings which Providence had designed as so many Motives to excite their Gratitude and Obedience, into the Means of Riot and Excess. The Prospect of Death at the

remote Distance of several Ages, did not disturb their Repose in the midst of their sinful Pursuits; they were not alarmed by the Voice of the Thunder, nor punished by the Severity of Seasons, nor brought to a just Sense of their Duty and Dependence by any other salutary Admonitions or Afflictions; and therefore they gave themselves up to evil Courses, and criminal Pleasures, without Remorse or Restraint. Nothing but an universal Change in Nature could be sufficient to put a Stop to the growing Wickedness of Mankind; and therefore God thought fit not only to destroy the Inhabitants of the first World, but also to produce an Alteration in the Earth itself, to change the Disposition of the Air, and the Order of the Seasons: By these means he contracted the Life of Man into a shorter Span, and made it more laborious and painful. He did not indeed immediately vouchsafe to apply that saving Remedy which alone could thoroughly purge and reform the Heart of Man; but he did effectually put it out of the Power of the second Race of Men; to go those Lengths in Iniquity which the Inhabitants of the former Earth had done.

But it may be asked how this terrible Change could be effected? As if the Removal of a single Line out of its Place, by the Hand of God, were not sufficient to cause an universal Revolution in Nature. He took the Axis of the Earth, and inclined it some few Degrees towards the Northern Stars; and, behold! this little Deviation produced a thorough Change in the Order and Oeconomy of the natural System of the World, and seemed to give Birth to new Heavens and a new Earth*. By this Inclination of the Axis, the Equator of Necessity became depressed below the Sun, and that bright Luminary immediately darted its scorching Rays on one Hemisphere, whilst the sharpest Frost and Cold exerted their utmost Severity on the other. Hence proceeded Condensations and Rarefactions in the Air, causing violent Commotions in the Atmosphere, whilst warring Winds and Tempests raged with embattled Fury, through the middle Regions of the Sky; the Windows of Heaven were opened, and the superior Waters, being condensed by the Violence of

* 2 Pet. iii. 7.



The Orbit of the Earth in its Annual Revolution.

Tome sculp.

the Shock, poured down in Torrents upon the Face of the Earth; the Earth felt the universal Concussion, and shaking from its very Foundations, broke in pieces under the Feet of its wicked Inhabitants, and plunged into the subterraneous Waters; by this Disruption of the Crust, the Fountains of the great Deep were broken up, and spouted forth their Treasures over the disjointed Mass. In a word, from the Concourse of the superior and inferior Waters was produced an universal Deluge, which drowned the Globe.

As God did, by the Agency of the Sun and the Winds, bring a Flood upon the Earth, so likewise did he employ them as Instruments to dismantle it again of the Waters, which partly subsided into those Places which were more depressed than others, and partly ascended up again in Vapours into the Atmosphere. From this time forward, the Earth having its Axis inclined twenty-three Degrees to the North, and consequently presenting different Parts of its Body, at different Distances from the Equator, to the perpendicular Influence of the Sun, varied its Aspects and Situation with regard to the Sun every Day, for six Months together, and daily re-assumed them during the other six Months of its Revolution in its annual Orbit. This Diversity of Seasons, and these Vicissitudes in the Air, did necessarily occasion an Alteration in the Temperament of the human Body, and contracted the Life of Man into a narrower Space. The Posterity of Noab did indeed, for a few Generations, still retain some of the Vigour of their Forefathers, till the human Body, by gradual Decays, became, both in Constitution and Duration, such as was natural and proportioned to the Impressions of the Air, and the Influence of the Seasons; as the Children of some gigantick Prussian, by being carried into Lapland, will in a few Generations be brought to the Standard of the Climate, and degenerate into native Laplanders. Let us now pass to the other Consequences of the Deluge, pursuant to those Informations we receive from the History of Moses, and from those Footsteps which still remain of it in Nature.

If then God, by giving this Inclination to the Earth's Axis, produced these violent Commotions in the Air, and these Subsidences in the Surface of the Earth, how great must

must have been the Astonishment of the Children of *Noah*, upon the Sight of this surprizing Change in the Place of their Habitation, when, instead of delightful Vales, and Hills covered with that verdant Carpet which overspread the Face of the primitive Earth, they saw nothing on the *Gordyan* Mountains, on the Top of which the Ark first rested, but hideous Caverns, and monstrous Rocks, which rose promiscuously out of the Ruins of the old World, some of which exalted their pointed Tops under a Covering of Snow, whilst thick Fogs and Vapours concealed the gloomy Summits of others! Nor did the Aspect of the Heavens appear less strange and surprizing. The Return of the Clouds, which had been to them, before, the Forerunners of the Deluge, could not fail to alarm them afresh, and fill their Minds with dreadful Forebodings. But how agreeably were they surprized, and their Fears banished, when the declining Sun darted his chearing Rays through the gloomy Veil of the Heavens, and painted on the Skirts of an opposite Cloud, a beauteous Bow, majestically decked in all the Variety of the most lively Colours! As this new and glorious Object only made its Appearance towards the End of Rains * and Storms, it became to Man a natural Sign of an ensuing Serenity, and a Pledge of fair Weather. Several Interpreters of Scripture, giving into that common Opinion, that the Rainbow is as antient as the Creation, have taken a great deal of Pains to find out Arguments, in order to justify the Use which *Moses* makes of this *Phænomenon*; whereas our Hypothesis clears him from any Necessity of being defended, and supposes the Rainbow, as his History plainly implies, to be a new *Phænomenon* unknown before the Deluge: Now if it was unknown before, so also was the Rain; and if there was neither Rain nor Storm in the Time of the Antediluvian Earth, our Conjecture is consequently both rational and probable.

If, pursuant to our Hypothesis, the Surface of the primitive Earth was hollowed, and made unequal, by some

* The Rainbow is caused by those Rays of the Sun which falling on the Drops of Water in a Cloud, are differently reflected and refracted to the Eye of the Spectator, placed betwixt the Sun and those Drops. The same Rainbow is not seen by different Persons, but every one sees a distinct Bow.

one universal Concussion or Dislocation of its Parts, it will necessarily follow, that we must find in Nature evident Signs of a twofold Constitution in our Globe, or, in other Words, distinctly perceive what the Structure of it was according to its first Creation, as different *Strata* of black Earth, Sand, Clay, and other Matters lying one upon another, in such exact Order and Regularity as plainly denoted the Hand that laid them to be divine; but at present disjointed, broken, and uneven, yet so as to preserve, under this general Disorder, convincing Marks of that great Change which the divine Justice wrought in the Constitution of the Earth.

I. The Surface of the Globe being composed of friable Earths, and long *Strata* of Stones, the Earths must have given way in this universal Disorder, and have fallen into pyramidal Figures in several Places, as is natural to all Earths which we cast from us; whereas the Masses of Stones being more difficultly separated, must have broken and fallen into irregular Heaps in many Places, in some inclining to the Plane of the Horizon, in others parallel to it, according to the Nature and Disposition of the Earths which supported them. And this Effect is confirmed by Experience, we finding in all Countries long Ridges of Mountains, the highest of which are nothing but large Masses of broken Rocks, whose Sides are laid bare by the falling away of the Earth; we likewise find almost in every Part of the Earth long *Strata* of Stone on the Declivities of Mountains, which have the same Slope and Inclination to the Horizon with the Mountains themselves, and which were formed there before the Deluge by horizontal Currents of Water running through Beds of Sand having the same Situation. Now what other Reason can be given for their present inclined Posture, but that the Earth, which was their Basis, subsided unequally, and consequently destroyed their former Parallelism? We always find, that those Beds of Stone, which are under Ground, lie more parallel to the Surface of the Earth; the Reason of which is, either that they were petrified since the Deluge, or that they are situated on an horizontal Basis; though, generally speaking, the Superficies of the Plains of the Earth does run gradually sloping down to the Bottom of the Sea, as is found by Ex-

perience upon founding. It is also observed in all Islands, that their middle Parts are more elevated than the rest, from which there lies a Descent down to the Sea, and which is continued under it. This is an evident Sign of the Subsidence of the Earth. Thus the *Apennine* Mountains are continued quite through the Middle of *Italy*, from the Bottom of which there lies a Declivity on each Side to the two neighbouring Seas. Such is the Situation of the *Cordeliers* along the Country of *Peru*, of the *Apaches* in *Mexico*, of another long Ridge of Mountains on the Coasts of *Brazil*, and of several others along the Continents of *Africa* and *Asia*.

II. By a necessary Consequence of the same Catastrophe, it will follow, that as the several Parts of the Earth continue to descend in a Slope to that Point of Contact where any two large Masses of the Crust, by its subsiding, formed an Angle at their Bases, and rested upon each other, the Waters that remained upon the Earth after the Deluge must inevitably have repaired to those Places which were most depressed; and consequently we ought to find larger, and more Islands near those vast Tracts of Land which we call Continents, than in the middle of the Ocean, where the Subsidence of the Earth is greatest. And that this is so, will appear upon taking a slight Survey of the terrestrial Globe. Thus the Islands of the *Archipelago* are visibly the Remains of that Land which formed the Communication between *Europe* and *Africa*; as the *Antego* and *Caribbee* Islands are, of that which joined *North* and *South-America*.

III. Another necessary Consequence of the Subsidence of the Earth's Surface is, that the antient *Strata* of Stones and Metals must have been broken in several Places, and in some pierced through and through by the falling in of the upper Crust; which exactly agrees with the Accounts of all those who have made Observations on Quarries and Mines *.

IV. The Waters of the Sea, by running down into those Places which are most depressed, must have changed their Abode, and have left in their former Quarters, which we

* See the Abridgment of the Philosophical Transactions, Vol. 2. and more particularly the Nature of Mines, by *Georgius Agricola*, de *Re metallicâ*.

now inhabit, Sea-Plants, Fishes, and Shells; all which we find therein to our great Surprise,

V. Several Parts of the primitive Earth must have been undermined by the Waters of the Flood, and the Mountains in many Places have tumbled down on to the Plains, burying under their Ruins those marine Bodies which were intercepted by their Fall*. Hence proceeds that surprizing Confusion and Mixture of Substances which we sometimes find sixty or eighty Foot under Ground, as Rushes or Meadow Herbs, lying promiscuously with Masses of petrified Wood; sometimes Bricks, Coals, and wrought Metals, all in one undistinguished Heap, under which shall be a large Bed of Shells, sometimes of different Kinds, sometimes all of the same sort: Nor is it uncommon to find these large Collections of Shells, which were thus promiscuously thrown together at the time of the Deluge, petrified by the subterraneous Waters, and the Insinuation of a loamy Earth and Sand into their Pores. We find a Proof of this in several Quarries in the Neighbourhood of *Paris*.

VI. There has been found on the Top of one of the highest and most barren Mountains of all the *Alps*, a very large Tree over-turned, but preserved entire, and in its perfect Form†. There have been also found under Ground in some of the Northern Islands, which now produce nothing but a little Moss, huge Trees of different Kinds. These two Particulars, seemingly so surprizing, are easily and naturally accounted for from our Hypothesis: For these Places which are barren now were not so before the Deluge, there being then a perpetual Spring, and an universal Fecundity over the whole Earth: If then the Sun did formerly extend its genial Influence all the Year, as far as the Neighbourhood of the North-Pole, the Inclination of the Earth's Axis must of Necessity have produced that Change in the Situation of the Globe, by which it is not so well accommodated to the Purposes of Fertility and Vegetation as it was formerly: And if the Tops of the *Alps* did in antient Times produce great Trees, the Sterility of these Rocks at present must have been oc-

* See the Treatise, intituled, *De Corpi Marini*, &c.

† *Ibid.* as also the *Memoires de l'Academie des Sciences*, and *Woodward's Natural History of the Earth*.

caused by some general Revolution in Nature, which stript them of their nutritive Earth.

VII. I shall only add to the Proofs already brought in order to support my Hypothesis, one very obvious and common Remark. We often observe in those Dales or Hollows that lie betwixt two Hills, the same Number of *Strata* on both the opposite Sides; the same sorts of Earths, of the same Thickness, and generally answering one another: The same Order is likewise found in the *Strata* underneath in the Earth. From whence it almost demonstrably follows, that this Valley or Dale was occasioned by the subsiding of the intermediate Earth, which caused a Division in the *Strata* that were continuous before.

I might, my dear *Chevalier*, observe to you from the Emblems of the *Egyptians*, the Tradition of the *Indians*, and the Fables of the *Grecians*, especially that of *Erichthonius*, how careful the Antients were to preserve the Memory of some general Disorder caused in the Earth by the violent Concussion of Winds, and the Disruption of the Surface of it: but such Inquiries would lead us beyond the Compass of our Design, which was only to take a View of Nature; nor is there any Occasion for them at present, seeing whatever we can discover either upon or within the Earth, does sufficiently prove to you the Truth of those Facts which are related by *Moses*. I proceed next to discharge the other Part of my Promise, which was to give you a Notion of that Provision which is made in Nature for that universal Conflagration which shall one Day consume the Earth, and cause *the Elements to melt with fervent Heat* *.

God has ever since the Creation of the World made use of natural Causes and Means to execute his Designs. He has already employed the Agency of the Winds and Waters to destroy the Earth, for the Punishment of that wicked Race of Men that were its first Inhabitants; and will in like manner depute the Fire to be the Minister of his Vengeance on the second Earth, and to consume those wicked Persons who shall disgrace it by their ungodly Lives. It is therefore very probable to suppose that

* 2 Pet. iii. 10.

instead of creating new Fire for this Purpose, he will employ that which is already laid up in Nature's Store-house; the Fire is in Readiness under our Feet, and over our Heads, and only waits the Word of Command to obey the Orders of the Almighty. But as, in the antediluvian World, Men did not consider what vast Reservoirs of Water were kept in Store above in the Heavens, and also in the great Deep underneath in the Earth, and therefore looked upon those Warnings and Premonitions that were given them of the approaching Deluge, as Fables and idle Dreams; so the Men of this Generation, not seeing the Fire, that does actually surround them on every side, give no Heed or Credit to what is told them of the universal Conflagration of the last Day.

All Nature is replete with that active Principle or Element, which we call Fire, and which nothing but the Hand of God restrains from breaking loose till that appointed Time, when he shall commission it to act with full Power. That the Fire is diffused all round us, and is extended from the fixed Stars and the Sun to our Globe, does appear from hence; that the Light, as was shewn before, does fill all that Space, which is plainly nothing else but the Fire itself, which produces different Sensations and Effects, as it is differently modified and impressed upon us. When it strikes our Bodies in an irregular and confused Motion, or after the Manner of a Vortex, it produces Heat; when it comes to our Eyes in straight Lines, it causes Light; when weakly, though directly, reflected to us from the Disk of the Moon, it produces Light without Heat; when collected in the Focus * of a concave Burning-Glass, or of a transparent convex Body, it gives a strong Light, and burns whatever it touches; its Power is always in Proportion to its Quantity; and the different Sensations it excites in us, arise from the different Motions and Modifications impressed upon it.

This subtle and active Element is distributed in great Abundance all round the Earth; nay, it penetrates into the

* The Focus of a Burning Glass, or of a Lens, is that Point in the Air, where the Rays unite at a certain Distance from the concave Mirror which reflects them, or from the convex Glass or Lens, which refracts them.

most secret Recesses of it; it is dispersed in all the Woods that cover it; it lurks in the Grease of Animals whose Bodies cannot subsist without it; but it abounds still in greater Plenty in the Bitumens, Oils, Sulphurs, Sea-Coal, and in those vast Beds of Turf which lie hid under the Surface of the Earth. It is continually at Work in the hot Springs and Volcano's under Ground, whose Number and Force is found rather to increase than to diminish. It sometimes displays its dreadful Power in the upper Regions of the Air, and in loud Volleys of Thunder, and all the flaming Artillery of the Sky, beats a dismal Prelude to the universal Conflagration. How amazing the Voice of that Thunder! How tremendous the Flashes of that Lightning, which make the wild Beasts of the Forest afraid, and to hide their Heads! nay, which dart Terror and Dismay into the stoutest Hearts, and make even Kings acknowledge their Weakness and Dependence! The secret Horror, which every Man feels in his own Breast at such a time, is a tacit Confession of the irresistible Force of that all-devouring Fire, and does, even maugre all his Endeavours to the contrary, as it were, force upon his Mind the Belief of that final Conflagration, which, when in a State of Tranquillity, or the Height of Jollity, he so much looks upon as a Fable.

Fire does hold such an universal Sway in Nature, that even Water itself is not without an Admixture of this Element; for it grows hard and congeals when the Fire leaves it, and is only restored to a State of Fluidity by its entering into it again, and by that Separation which it causes in its Parts by Rarefaction. So far is Water from being an Enemy to Fire, as is generally imagined, that it no otherwise prevents its acting upon Wood, or any other combustible Matter, than by laying hold of the Particles of it, and flying away with them on the Wings of the rarefied Air; nor does it extinguish, but only absorb the Fire, it being with regard to Fire, the same as a Sponge is to Water. The Sponge has no natural Aversion or Antipathy to the Water, and the only Reason why the latter disappears, upon the former's being steeped in it, is because the one insinuates itself into the Pores of the other; so in like manner, the Fire does not shew itself by any visible Effects in the Water, because it is, as
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it were, sheathed and enveloped in it; insomuch that we may with some Degree of Truth affirm, that the whole Mass of Waters in the Sea is an Ocean of Fire, seeing there are not two distinct Drops of this Element, which do not owe their Fluidity to some Particles of Fire inclosed within them; for as the Sponge, or any other porous Body which imbibes the Water, does restrain it from Motion, so the Water does absorb and confine the Fire.

The Fire then is dispersed all over the Face of Nature; it makes its utmost Efforts every where to overcome all Opposition, and to break loose from its Confinement; but it does not every where prevail, for want of auxiliary Forces. What the united Strength of thirty Children would easily overthrow, that of a single one would not be able to move; so likewise the Particles of Fire in any Body must remain dormant and inactive, till they concur with united Strength, to force their way through all Obstacles that oppose their Fury. Thus we see that all those innumerable fiery Corpuscles, which surround us on every side, are so many Enemies, which are conspiring and plotting the Destruction of our Habitation, and which only wait till God shall give the Word of Command, for them to collect their scattered Forces in order to accomplish it. A very learned and ingenious Heathen took occasion from reflecting on the Danger we are continually in of such a Catastrophe, to remark, that it was the greatest Miracle in the World, that every thing in Nature was not consumed by Fire every Day since the World began*.

You are by this time, my dear Chevalier, I doubt not, thoroughly apprized of the Usefulness and Tendency of Nature, to promote the Cause of Piety and Religion, and of those publick Attestations with which it supports the Truth of Revelation; and consequently understand also wherein the true Excellence and Use of the Study of Nature does consist. If Man is the only Creature upon Earth that is capable of knowing, loving, praising, and enjoying his Creator; and if every thing which he has placed round about us, was with a Design to conduct us to himself, all Knowledge, which is not directed to this End,

* Excedit profecto omnia Miracula ullum fuisse Diem, in quo non cuncta conflagrarent. *Phn. Hist. Nat. L. 2.*

is not Wisdom, but Folly ; all Learning and Study which sets God on one hand, and Nature on the other, is an idle and unprofitable Amusement, and nothing better than lost Labour, ending in Pride and Ignorance, Error and Uncertainty. To fill our Heads with several Particulars of Nature, without directing our Thoughts and Inquiries to the Author of it ; to be sensible of all his Favours and Blessings, without being a whit more religious or more grateful, is to imitate those senseless rich Misers, who, without knowing the Use of Silver or Furniture, are continually heaping up Plate upon Plate, and Tapestry upon Tapestry, and convert their Houses into mere Warehouses of Household-Goods, without having them furnished in any decent or tolerable manner. Several Persons regard Natural History, merely as a genteel Accomplishment ; others apply themselves to it, in order to bear a Share in the Disputes of the Learned ; some to form a Collection of Curiosities ; and the greatest part by way of Amusement or Relaxation from their more severe Studies, or the Business of their respective Callings. But how do Men disgrace this excellent Study, by such mean and narrow Views ! The Prospect of Nature was laid open to us for more noble Purposes, to make us better Men, and to inspire us with the most exalted Sentiments of Love and Gratitude towards him, who is the Author and Giver of all good things. It was doubtless the Design of God in that Beauty and Order, which he has displayed in every Part of the Creation, to attract our Eyes, and invite our Attention ; but at the same time that he has given us Abilities and Powers to discern clearly the Use and Fitness of things, he has cast a Veil over their Essences, and shut us out from the Knowledge of that particular Structure and Mechanism, from which their several Properties and Qualities result. The Design of God herein is very manifest. It was not his Intention to satisfy our Curiosity, and to give us a full and comprehensive Knowledge of his Works, but to affect our Minds with the Sense of his Benefits. Natural History, therefore, is the History of his Presents, and the greater Progress we make in the Study of it, the deeper Sense shall we have of the Obligations we lie under to him ; but to know how much we stand indebted to the Divine Favour, and to be unmindful of our

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great Benefactor, is to join Ingratitude to Knowledge, and consequently to aggravate our Crime; all our Learning being of no farther Use or Value, than as it tends to influence our Conduct, and to give us right and worthy Conceptions of the Deity. The Heart is with regard to Man, what Man is to the natural System; for as there would neither be Beauty, Order, nor Fitness in the World, were it not for Man, for whose Use and Benefit they were designed; so neither are Study, Learning, or any other Endowments in Man, available to any good Purpose, if the Heart be not bettered by them. Every thing refers itself to the Heart of Man, and the grateful Heart refers all to God.

I am,

S I R, &c.

The END of the THIRD VOLUME.

I N D E X.

- A** *CID*, what, p. 216.
Acids, their Uses, *ibid.*
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